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NUTRITIVE VALUE FOR DEER OF SOME FORAGE PLANTS IN THE SIERRA NEVADA[1]

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INTRODUCTION

Various investigations into the problems of managing North American deer have demonstrated that local populations often are limited by inadequate supplies of nutritious forage. With the control of large predators and the enactment and enforcement of stringent protective laws, many deer herds have increased to the point where they have outstripped their food supplies and large numbers have perished, either from malnutrition or by disease which becomes epizootic in undernourished populations. It is now almost a maxim among game managers in the United States that die-offs among deer are a manifestation of inadequate nutrition.

Food habits studies of deer on many ranges have shown that the animals actually consume small quantities of a great variety of plants, but in each area they seem to be largely dependent for their sustenance during the critical season of the year, ordinarily the winter, on a few species which commonly are referred to as *Key Forage Species*. Symptoms of distress (lowered fawn production, disease, or malnutrition) usually become evident in local populations when the key species are over-browsed even though second choice foods which normally are lightly utilized may still be abundant. Practically all deer that die of malnutrition do so with full stomachs—but full of foods which will not sustain them. Thus the problem of adequate nutrition for deer is qualitative as well as quantitative, and it is important that we have a better understanding of the chemical composition and actual nutritive value of forage plants in order to understand the limitations imposed by range on deer populations.

PREVIOUS INVESTIGATIONS

Previous investigators faced with this problem have used two principal approaches in studying deer nutrition: (1) chemical analysis of

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The writer expresses appreciation to Dr. Harold H. Goss of the University of California College of Agriculture at Davis, whose guidance and help aided greatly in this study; to Dr. A. Starker Leopold of the Museum of Vertebrate Zoology under whose direction this study was made, and to the members of the California Department of Fish and Game disease and food habits laboratory, without whose cooperation this study would have been impossible.

forage samples and (2) actual feeding experiments with penned deer. Some have used both in combination, as was done in this study.

Feeding Experiments

Nichol (1938) in Arizona fed captive deer to determine quantities of feed needed for maintenance. He found they required 2.2 pounds of hay and grain or 2.3 pounds of native feeds daily per 100 pounds live weight to maintain themselves in good condition. Other studies designed to test qualitative differences in feeds have been reported by Maynard, et al. (1935), Atwood (1948), and Davenport (1939). All found that some forage species are more nutritious than others, but that, in general, deer do better on mixtures of foods than any single species. Maynard et al. (1935) and Forbes et al. (1941) ran digestion trials to determine the digestive capacities of deer, in comparison with goats and rabbits respectively. It was found that goats were better able to digest roughages (crude fiber) than deer, and that deer were more efficient than rabbits.

Chemical Analysis of Forage Plants

Hellmers (1940) in Pennsylvania made a study of the monthly variation in the chemical composition of deer foods and found that the nutritive values decreased during the winter. Gordon and Sampson (1939) also found a decrease in nutritive value of foothill range plants in California from summer through fall and winter. Aldous (1945) in Nevada found by analysis of clippings of bitterbrush that the twig tips were more nutritious than basal sections. Reynolds and Sampson (1943) in California found that the sprouts of burned-over chamise were more nutritious than those from unburned plants. Likewise Einarsen (1946) in Oregon showed that the protein content of forage plants from burned areas was higher than from unburned areas, and correspondingly that the burned-over areas had a higher population of heavier and healthier deer. Swift (1948) in Pennsylvania observed that in grain and hay fields the deer singled out certain areas where the plants proved to be higher in fat, calcium and phosphorus.

In summary, it seems that deer eat a wide variety of foods, but that some of the foods are more important in *sustaining* the animals than others. There seems to be considerable variation in quality between forage species, and likewise there are seasonal changes within a species during different growth stages. Sprouts are more nutritious than old growth and a given twig will lose nutritive value through the dormant winter season. The tip of a twig, which normally is the portion consumed first, is richer than the basal section. In general, the best foods (most palatable and most nutritious) are high in crude protein and sometimes also in minerals and fats.

FORAGE STUDIES ON THE JAWBONE WINTER RANGE

In 1947 the University of California undertook an intensive investigation of a herd of deer that winter on Jawbone Ridge in central Tuolumne County on the western slope of the Sierra Nevada. This study was made in cooperation with the California Department of Fish and Game with

Pittman-Robertson funds and included range and food habits investigations, and a study of general health and productivity in the herd. A report on the Jawbone study has now been published, Leopold et al. (1951). Work on nutritive value of browse species was centered here because of the background material available.

The Jawbone winter range occupies about 24,000 acres on the lower part of Jawbone Ridge, which lies between the Tuolumne River on the south and the Clavey River on the north and west. Vegetation types on this area are listed in Table 1. Of the five types, the "mixed brush," occupying a little over a quarter of the area, furnishes the bulk of the good deer forage.

TABLE 1

Areas Occupied by Various Classes of Vegetation on the Jawbone Winter Range

Vegetation type	Acres	Percent
Coniferous timber	10,832	45.5
Mixed brush	6,650	28.0
Oak woodland, brush understory	4,661	19.6
Oak woodland, grass understory	1,275	5.3
Grass or weed openings	373	1.6
Totals	23,791	100.0

From the standpoint of deer nutrition the more important brushy species of plants on the winter range are: (1) buck brush, (2) mountain misery, (3) manzanita, (4) oaks, and in addition, grass in the spring.

TABLE 2

Stomach Contents of 24 Deer Collected on the Jawbone Winter Range in 1948-49
(From Ferrel and Leach, 1950)

Forage plant	Percent volume	Percent occurrence
Mountain misery (*Chamaebatia foliolosa*)	37.3	75
Buck brush (*Ceanothus cuneatus*)	12.2	63
Manzanita (*Arctostaphylos* spp.)	11.2	67
Grass (*Graminae*)	9.1	92
Oaks unidentified (*Quercus* spp.)	6.7	42
Maul Oak (*Quercus chrysolepis*)	4.6	13
Christmas berry (*Photinia arbutifolia*)	4.0	21
Stone crop (*Sedum spathulifolium*)	3.1	4
California Black Oak (*Quercus kelloggii*)	3.0	29
Incense cedar (*Libocedrus decurrens*)	3.0	38
Willow (*Salix* spp.)	1.9	8
Miscellaneous food items	1.4	88
Forbs unidentified	1.3	58
Browse unidentified	1.2	38

Table 2 presents the results of a food habits study made by Ferrel and Leach (1950), based on stomach samples of 24 deer taken from the Jawbone winter range. Range measurements and field observations show that buck brush is clearly the key forage species, and that mountain misery is taken in quantity only late in the winter when the buck brush becomes heavily browsed.

The diet appears to be influenced by preference and is only secondarily a function of abundance. This would be much more striking if it were possible to illustrate the heavily browsed condition of the buck brush and the light use of the more abundant manzanita and mountain misery.

In comparing the nutritive value of some of the foods eaten by Jawbone deer, the basic methods of previous investigators were used, i.e., (1) chemical analyses of twig and leaf samples to determine percent of fats, carbohydrates, protein, crude fiber and mineral matter, and (2) actual digestion trials. The digestion trials covered only one species (buck brush) to determine the digestibility of the plant, as well as the digestive coefficients of the fat, carbohydrates, protein, crude fiber and mineral matter.

Chemical Analyses of Deer Foods

For the chemical analyses, samples of buck brush (*Ceanothus cuneatus*), mountain misery (*Chamebatia foliolosa*), deer brush (*Ceanothus integerrimus*), hardtack (*Cercocarpus betuloides*), and two species of manzanita (*Arctostaphylos patula* and *A. mariposa*), were collected at various times during two winters from the Jawbone winter range. Samples of two species, snow brush (*Ceanothus cordulatus*), and bitter cherry (*Prunus emarginata*), were collected from the Jawbone summer range. Samples of six species were collected from the summer range of the Tehama deer herd, in the area between the north side of Lake Almanor, Plumas County, and Lassen National Park. These were snow brush, squaw carpet (*Ceanothus prostratus*), tobacco bush (*Ceanothus velutinus*), serviceberry (*Amelanchier alnifolia*), mazanita (*A. patula*) and bitterbrush (*Purshia tridentata*).

Samples, unless otherwise noted, consisted of the terminal two inches of twigs and leaves of the plants. All were collected at random from a number of different plants in the same general area with the idea of approximating the amount of forage removed by the deer. The analyses were made at the California Department of Fish and Game Laboratory in Strawberry Canyon, Berkeley. The Association of Official Agricultural Chemists methods of analysis were used throughout.

Jawbone Range Samples

Buck brush (*Ceanothus cuneatus*)—Seven samples of buck brush were collected, one in October, one in December, one in February and four in April. Results of the analyses are given in Table 3.

TABLE 3

Chemical Analyses of Forage Plants

Where collected	Date collected	Name of plant	Chemical composition in percent (oven dry)				
			Crude prot.	Fat	Min. matter	Crude fiber	N.F.E.
Area 1, Jawbone	Apr., 1949	Buck brush browsed	9.0	3.3	4.0	25.9	57.9
Area 1, Jawbone	Apr., 1949	Buck brush unbrowsed	10.0	4.2	5.0	23.1	57.8
Area 2, Jawbone	Apr., 1949	Buck brush browsed	10.5	3.3	4.6	26.1	55.5
Area 2, Jawbone	Apr., 1949	Buck brush unbrowsed	11.6	3.6	4.6	22.5	57.7
Jawbone	Oct., 1948	Buck brush	11.4	7.2	5.6	13.1	69.9
Jawbone	Dec., 1949	Buck brush	8.6	6.1	4.6	17.5	63.1
Sonora, Tuolumne Co.	Feb., 1950	Buck brush terminal 12 inches	8.4	4.8	3.7	28.9	54.3
Jawbone	Oct., 1948	Mountain misery	9.9	10.4	10.5	14.2	55.1
Jawbone	Apr., 1949	Mountain misery	8.8	5.3	3.8	17.4	64.8
Twain-Harte, Tuolumne Co.	Apr., 1949	Mountain misery	7.5	5.0	2.6	23.0	61.8
Davis, Calif.	Oct., 1948	Mahogany (hardtack)	15.2	2.9	5.0	20.3	56.5
Jawbone	Oct., 1948	Mahogany (hardtack)	14.0	7.1	6.7	15.0	57.2
Jawbone	Dec., 1949	Mahogany (hardtack)	11.1	4.5	4.6	15.7	63.3
Jawbone	Oct., 1948	Deer brush leaves	10.0	2.9	11.2	10.0	63.8
Twain-Harte	Apr., 1950	Manzanita, (*A. patula*) leaves	7.5	8.4	3.4	11.2	69.5
Lake Almanor	July, 1949	Manzanita, (*A. patula*)	14.6				
Twain-Harte	Apr., 1950	Manzanita, (*A. mariposa*)	4.7	9.4	2.6	13.6	69.7
Belle Mdws., Tuolumne Co.	July, 1949	Snow brush	16.2	2.8	4.7	14.7	61.7
Lake Almanor	July, 1950	Snow brush	20.3				
Lake Almanor	Aug., 1950	Snow brush	15.3				
Lassen Park	Aug., 1950	Snow brush	17.1				
Belle Mdws.	July, 1949	Bitter cherry	15.2	5.3	7.5	15.1	56.8
Lake Almanor	July, 1949	Squaw carpet	13.7				
Lake Almanor	Aug., 1949	Squaw carpet	11.2				
Lake Almanor	July, 1949	Serviceberry	15.1				
Lake Almanor	Aug., 1949	Serviceberry	13.4				
Lake Almanor	July, 1949	Tobacco bush	19.8				
Lake Almanor	Aug., 1949	Tobacco bush	13.8				
Lake Almanor	Aug., 1949	Bitterbrush	13.7				

The samples collected through the winter show a progressive decrease in nutritive value and a corresponding increase in crude fiber. Protein content drops materially from October to February. By April, however, the new buds were swelling and protein content increased. Fat content and nitrogen-free extract drop throughout the period in all the samples.

The four samples of buck brush collected in April were taken specifically to determine whether there were measurable differences in plants that were heavily browsed and those that had grown out of reach of the deer. Samples were taken from each of two areas. There were slight differences in the browsed and unavailable plants, the unavailable plants being a little higher in protein, fat and mineral matter and lower in crude fiber.

These differences probably result from heavy browsing removing all the buds and terminal growth from available plants while the unavailable plant samples still bore buds or twigs. There are differences in the composition of the plants from the two areas, however, resulting possibly from differences in the soil. The plants growing on shallow soil of volcanic origin had a lower protein content than the plants from a deep soil of granitic origin.

Mountain misery (*Chamaebatia foliolosa*)—This species is a low-growing member of the Rosaceae having a powerful and penetrating odor during the summer and fall. This odor apparently comes from an oily exudate covering the leaves of the plant and tends to disappear during the winter, probably being washed off by the rain and snow. The deer do not appear to consume much of the mountain misery until late winter, when the odor has largely disappeared.

Mountain misery shows a clear loss in protein, fats and mineral matter, a gain in crude fiber, and a loss in nutritive value during the winter. The most striking thing about the analysis of the mountain misery is the great drop in fat and mineral matter from October to April. The loss in odor probably is correlated with the reduced fat content in the spring, the odor doubtless arising from aromatic oils which are leached out in winter. The high mineral matter content found in the mountain misery in the early fall may be caused by dust adhering to the oily leaf surface of the plant which, of course, leaches off with the oils during the winter leaving a low mineral matter content for the analyses in the early spring.

Hardtack (*Cercocarpus betuloides*)—Hardtack or birch leaf mahogany is not an important item in the diet of the deer because it is scarce on the winter range. It is included here because it is a favored food when obtainable. Two samples were obtained from the winter range, one in October and one in December. Also, a sample was collected from the arboretum of the University of California College of Agriculture at Davis, California. This plant was growing in rich black Yolo loam, considered to be one of the most fertile soils in the Country. It was obtained to see if the rich soil made any difference in the chemical composition of the plant.

The most noticeable thing about the analyses of the hardtack is the high crude protein content of all the samples. This may be the reason it is so highly preferred by deer. The sample obtained from Davis was higher in protein and crude fiber and lower in fat and mineral matter. The correlation of high protein with good soil is to be expected, but the reason for the low mineral and fat content and high crude fiber is unknown. Again there was a drop in protein during the winter and a loss in nutritive value.

Deer brush (*Ceanothus integerrimus*)—This is another plant that because of its scarcity is not an important item in the diet of the deer on the winter range. Like hardtack, however, it is a favored food when obtainable, and was analyzed for that reason. The sample had a fairly high crude protein content, and again this may be the reason that it is a preferred deer food; although, the high mineral content may influence the preference for this plant.

Manzanita (*Arctostaphylos* spp.)—Two species of manzanita predominate on Jawbone Ridge—*A. patula* and *A. mariposa*. No attempt was made in the food habits study to distinguish between the two species, but from field observations it appears that *A. patula* comprises the bulk of the manzanita taken, and that *A. mariposa* is rarely utilized, though it is much more abundant.

The samples of both species were high in fats, the main difference between the two being in mineral matter and crude protein. The more palatable, *A. patula*, proved to be significantly higher in protein and

mineral matter. Both manzanitas are low in protein when compared with the better browse species and probably are low in nutritive value.

Snow brush (*Ceanothus cordulatus*)—This is the most important forage species on the Jawbone summer range and comprises the largest single item in the diet of the deer. Snow brush is also probably the most abundant of the forage plants on the summer range.

Bitter cherry (*Prunus emarginata*)—Bitter cherry is not one of the more important food items on the summer range, but it is one of the preferred foods, and wherever it occurs a browse line is quite noticeable. This sample was also high in protein content.

Lake Almanor Samples

Samples of six of the more important forage plants from the Lake Almanor summer range were analyzed only for crude protein. These samples were collected for two successive months, July and August, 1949.

Snow brush—Here again snow brush has the highest crude protein content, and it is also the most abundant plant on the summer range, as well as forming the bulk of the deer's diet during the summer.

Serviceberry (*Amelanchier alnifolia*)—Serviceberry is one of the more highly preferred foods, but it is rather scarce and forms a small part of the diet.

Squaw carpet (*Ceanothus prostratus*)—Squaw carpet is a common plant on the Lake Almanor summer range and is taken to some extent by the deer, but it forms a small item in the forage picture.

Tobacco bush (*Ceanothus velutinus*)—This member of the Ceanothus family rivals snow brush in its abundance on the Lake Almanor summer range, growing in extensive mixed stands with manzanita. Tobacco bush is high in protein, but does not seem to be one of the preferred foods. It is suspected that its occurrence in the deer's diet is more a factor of abundance than of preference.

Bitterbrush (*Purshia tridentata*)—Bitterbrush is found on the northwest side of the Lake Almanor summer range in certain areas in limited quantities. Wherever found it shows evidence of heavy deer use and appears to be a highly preferred food.

Manzanita (*Arctostaphylos patula*)—Manzanita is one of the most abundant plants on the Lake Almanor summer range. It appears to be little used by deer despite its high protein content. The high protein content is probably due to the lush new growth of buds and twigs that were selected for the sample analyzed.

All these forage plants on the summer range are exceptionally high in crude protein and all show a decline in protein from July to August. This leads to the belief that these plants are highest in crude protein and probably are highest in nutritive value during the early part of the growing season. Thus deer coming from the winter range in poor condition almost immediately upon reaching the summer range have available highly nutritious foods. Just what effect this has on fawn production is not known, but it most certainly must help in lactation of the does.

Summary of the Chemical Analyses

Table 4 is a summary of the analyses of the forage plants discussed. Six are from the Jawbone winter range, two from the Jawbone summer

TABLE 4

Average Chemical Composition of the Forage Species Analyzed (Without Regard to Date of Collection) and of Alfalfa Hay

Forage species	Time of year samples coll.	Number of samples	Crude protein	Fat	Min. matter	Crude fiber	N.F.E.
Lake Almanor Summer Range							
Snow brush	Summer	3	17.6	------	------	------	------
Ceanothus velutinus	Summer	2	16.8	------	------	------	------
Manzanita	Summer	1	14.6	------	------	------	------
Serviceberry	Summer	2	14.2	------	------	------	------
Bitterbrush	Summer	1	13.7	------	------	------	------
Squaw carpet	Summer	2	12.4	------	------	------	------
Jawbone Summer Range							
Snow brush	Summer	1	16.1	2.8	4.7	14.7	61.7
Bitter cherry	Summer	1	15.2	5.3	7.5	15.1	56.8
Jawbone Winter Range							
Mahogany (Hardtack)	Winter	3	13.4	4.8	5.4	17.0	59.0
Deer brush	Winter	1	10.0	2.9	11.2	10.0	63.8
Buck brush	Winter	7	9.9	4.6	4.6	22.4	59.5
Mountain misery	Winter	3	8.7	6.9	5.6	18.2	60.6
Manzanita (*A. patula*)	Winter	1	7.5	8.4	3.4	11.2	69.5
Manzanita (*A. mariposa*)	Winter	1	4.7	9.4	2.6	13.6	69.7
Alfalfa hay (from Morrison, 1949)	----------	----------	14.7	2.0	8.3	29.0	36.4

range and six from the Lake Almanor summer range. The samples are arranged in order of protein content which is thought to be the best index of general nutritive value. For comparison, composition of alfalfa is included in the table.

Alfalfa hay is considered to be the best of the domestic forage plants on the basis of nutritive value. In comparing alfalfa hay with the forage plants from the winter range it can readily be seen that hardtack is the only plant with a comparable crude protein content. The other plants range from slightly less to less than one-third of the protein content of alfalfa. All were lower in crude fiber than alfalfa and higher in fats, and with the exception of the deer brush lower in mineral matter. Most plants from the summer range are higher in protein than alfalfa, while all the plants analyzed are higher in nitrogen-free extract. Most forage plants from the summer range appear to be better foods than alfalfa hay. The more desirable browse species from the winter range compare very favorably except in protein content.

Comparing the various browse species from the winter range, it is interesting to note that the species high on the preference scale for deer are those that are high in protein. Hardtack, deer brush and buck brush, the more highly preferred foods, are the highest in protein and apparently in nutritive value. The substitute foods, mountain misery and *A. patula*, are lower in protein and nutritive value. And lastly, *A. mariposa* which is rarely utilized is the lowest in protein and probably has very poor nutritive value.

All the samples analyzed show changes in chemical composition through the winter, indicating a loss in nutritive value, as previously reported by Hellmers (1940) and Gordon and Sampson (1939). This change is particularly noticeable in crude protein. The general depreciation of the quality of forage through the winter coupled with exhaustion

of the better browse species leads naturally to problems of malnutrition in late winter.

THE DIGESTION TRIAL

During the summer of 1949 two male fawns were obtained and raised to use in digestion trials as soon as they had reached maturity. One fawn (No. 1) was obtained from Tehama County, California, and the other (No. 2) came from Contra Costa County, California. Both were Columbian black-tailed deer (*Odocoileus hemionus columbianus*).

Two pens 16 feet by 8 feet were built with well-drained cement floors and 8-foot hogwire sides. Feed troughs were installed, the design being a modification of the feeding troughs used by Nichols (1938).

The forage used in the digestion trial was buck brush (*Ceanothus cuneatus*) obtained from between Sonora and Columbia in Tuolumne County. This forage was taken from an area where there was a large quantity of unbrowsed brush available, rather than from Jawbone Ridge where the deer had browsed the brush down to the point where it would be extremely difficult to collect the amount needed to run the digestion trial. During the winter of 1948-49, 67 percent of the 1948 growth was removed from the buck brush by the deer on Jawbone Ridge. An attempt was made to remove approximately the same percentage of the plant for use in the digestion trials.

The forage was taken to the University of California College of Agriculture at Davis, California, and dried in a hot air oven at a temperature of 50-55 degrees centigrade for five days. It was then ground in a hammer mill until it would pass through a one-eighth-inch mesh screen. It was exposed to the air long enough for the moisture in the feed to come to an equilibrium with the moisture in the air.

In March, 1949, the two deer were nine months old and had been on hard feed for several months when the digestion trial was started. The feed was placed in pans, and the feed and pan weighed. The feed was left in front of the deer for 24 hours and then removed and the pan and remaining feed weighed. The difference was considered to be the amount of feed the deer had consumed in the 24-hour period.

Apparently the feed in this dried and ground condition was not very palatable to the deer. According to Nichol's (1938) findings that a deer needs about 2.3 pounds of forage per day for each 100 pounds of live weight, these two deer did not eat enough of the forage to maintain themselves. Where they should have consumed about 1.2 pounds apiece per day they only ate from one-third to three-fourths of a pound per day. The consumption varied from day to day with the individual deer. The feces were all collected and dried and stored in a jar until the trial was over; then they were carefully dried to drive off all moisture and weighed.

The deer were weighed and a blood sample taken at the start of the digestion trial. A red blood count was made from the blood samples and in comparison with counts found in wild deer showed the two deer to be in excellent condition at the start of the trial.

The two deer were placed on the buck brush diet four days before the trial was started. However, deer No. 2 would not eat enough of the feed to start a trial until the eighth day had passed. There was an eight-day trial on deer No. 2 and a 12-day trial on deer No. 1. The two deer were on the buck brush for 16 days. During this period they lost some weight.

TABLE 5

Weight Losses of Experimental Animals During the Digestion Trial

Deer No.	Weight at start of trial, lbs.	Weight at end of trial, lbs.	Loss in weight, lbs.	Percent of weight lost
1	57½	51	6½	11.3
2	65	56	9	13.8

Table 5 shows the weights at the start of the trial and the end of the trial and the loss of weight of each deer.

This loss in weight was probably not the result of the quality of the feed, but rather that the deer would not eat enough of it in the ground form to maintain their weight.

In eight days deer No. 2 consumed 1,699.1 grams of buck brush for an average consumption of 212.4 grams per day. During this time he voided 897.0 grams of feces for an average of 112.1 grams per day, and a total digestibility of 47.2 percent. Deer No. 1 in 12 days consumed 3,363.3 grams of buck brush for an average consumption of 280.3 grams per day. During this time he voided 1,695.5 grams of feces, an average of 141.0 grams per day and total digestibility of 49.7 percent.

TABLE 6

Digestive Coefficients of Buck Brush (Ceanothus cuneatus)

	T.D.N.	Protein	Fat	Min. matter	Crude fiber	N.F.E.
Deer No. 1	49.70	23.5	47.7	33.9	36.4	61.5
Deer No. 2	47.20	24.2	50.8	45.8	32.9	58.1
Average for both	48.45	23.8	49.2	39.8	34.6	59.8
Alfalfa hay	50.30	72.0	32.0	----------	43.0	71.0

The digestive coefficients of the deer for the buck brush and average digestive coefficients of alfalfa hay as given by Morrison (1949) are shown in Table 6. The comparison of the chemical analyses of alfalfa and buck brush are given in Table 4. The important difference in these two feeds appears to be in the protein, a feed high in protein is generally considered to be the more valuable.

In the digestion trial it will be noted that there were some differences in the digestive capacities of the two deer. It is interesting that deer No. 1 from Tehama County had a better digestibility of the crude fiber and the nitrogen free extract, and a better total digestibility of the buck brush. Although neither of the deer had ever seen buck brush before, the deer from Tehama County, where buck brush is one of the most important deer foods, was better able to assimilate it and started eating large quantities of it much sooner than the deer from Contra Costa County, where buck brush is relatively rare and not an important deer food.

The analysis indicates that buck brush has nearly as great a percentage of total digestible nutrients as has alfalfa hay. Evidently buck brush and probably some of the other wild forage plants are better foods, at least for deer, than has heretofore been realized. The most striking thing

about the digestion trial was the low digestibility of the protein in the buck brush. It proved to be only about one-third as digestible as the protein in the alfalfa. It is unusual to find protein so low in digestibility in a feed like buck brush that is so high in total digestibility. It would seem that the protein found in the feed late in the winter, when the protein content is probably the lowest of any time during the year, is of a very poor quality.

Morrison (1949) states that when a ration contains too little protein in proportion to the amounts of easily digested carbohydrates the digestibility of the ration may be seriously reduced. He also states that in feeds low in protein the digestibility of the protein itself may be reduced.

In discussing maintenance requirements of farm animals, Morrison says that animals on a ration below the maintenance level of required protein will gradually lose weight because of the continuous small waste of protein from the tissues of the body. Such undernourished animals cannot long survive. Gnilbert (1942) states that animals on a protein intake below the required maintenance level may have reproductive failures. From Einarsen's (1946) study on protein in the feeds utilized by deer in Oregon, it appears that protein is an important factor in deer nutrition. Thus it would seem that the protein may be the most important component of the feed, and the most important factor in the maintenance of the deer in good condition during the winter.

At the time the deer were weighed at the end of the trial another blood sample was taken. Table 7 shows the results of the blood counts and the changes in hemoglobin.

TABLE 7

Results of Blood Studies During the Digestion Trial

	Start of trial	End of trial
Deer No. 1—Red blood cells in millions	14.1	9.4
Percent hemoglobin	112	80
Deer No. 2—Red blood cells in millions	14.3	13.5
Percent hemoglobin	111	80

The difference between the two animals in red blood cell count did not correspond with the appearance of the deer. Deer No. 2 appeared to be in much poorer condition at the end of the trial and it lost more weight. However, a few days after the trial ended, deer No. 1 died of hemorrhagic septicemia. The organism was one of the Pasturella group causing fowl cholera. Diagnosis was made by the California Department of Fish and Game disease laboratory. Generally, healthy animals are not considered to be susceptible to this organism. Evidently the poor condition and low vitality of deer No. 1, which was reflected much more accurately in the red blood cell count than in its appearance, was responsible for the deer being susceptible.

SUMMARY

Chemical analysis of samples of deer forage plants show marked differences in composition of the various species. There are also great differences between the chemical composition of the forage plants utilized

by the deer during the summer, and those plants utilized by the deer during the winter. The most significant contrast between "good" and "poor" forage species seem to be in crude protein content. Plants preferred by the deer and generally considered the best forage on the basis of range evaluation prove to be consistently high in protein, while the "emergency" or "stuffing" feeds are low in protein. Differences in fat and mineral content exist and may have a bearing on palatability and general nutritive value, but seem to be less important than protein content.

Besides the differences between species it was found that protein content varies seasonally within a given species, being high in the summer and low in late winter. Average loss of protein content, October to April, proved to be about 25 percent in three species (hardtack, mountain misery and buck brush), represented by seasonal samples. The loss was most noticeable in hardtack and least noticeable in buck brush.

The plants on the summer range have the highest protein content in the spring and decline during the summer. Deer have forage of high quality available immediately upon reaching the summer range. This may have some effect on fawn production, and probably has a beneficial effect on lactation.

On an overstocked winter range such as Jawbone Ridge, the average nutritive value of the food consumed by an individual deer decreases through the winter because (1) the better terminal twig ends are consumed first, and (2) the protein, fat and mineral content of all species is decreasing throughout the winter. The low ebb in nutrition is reached in late winter, a time when most losses in deer herds occur.

Actual digestion by deer of buck brush proved (experimentally) to be as efficient as digestion of good hay by cattle, except that the assimilation of protein by the deer was low. Broad conclusions are not justified on the basis of this limited test. However, it is possible that inefficient or low protein digestion may further augment the protein deficiency ordinarily encountered by the deer in their late winter diet.

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STUDIES OF BLACK-TAILED DEER REPRODUCTION ON THREE CHAPARRAL COVER TYPES[1]

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INTRODUCTION

In August, 1948, a study concerning the effects of chaparral management on populations of the Columbian black-tailed deer (*Odocoileus hemionus columbianus*) was undertaken. At present this project is still in progress. The work has centered in the region lying just west of Lakeport, California. In this area the hills above about 1,500 feet are covered with a mixture of woody shrubs which are adapted to repeated burning. The three dominant species all crown-sprout after burning; they are chamise (*Adenostema fasciculatum*) which grows principally on south and east slopes, interior live oak (*Quercus wislizenii*) and eastwood manzanita (*Arctostaphylos glandulosa*), both of which grow principally on north or west slopes. These three species make up a little less than half of all the brush cover. About 18 other shrubby species make up the remainder.

At the beginning of the study three 1,000-acre study areas were selected. Each study area represented one of the three following chaparral cover types attainable by management: (A) opened chaparral, where the brush was interspersed with annual vegetation on some slopes, while scattered patches of heavy unburned brush remained on others; (B) wildfire burn, where the area was swept by a summer wildfire in 1948, with some unburned islands remaining; (C) heavy chaparral, unburned for six years or more. Later another heavy chaparral area (D) was added because part of Area C was burned in 1949. The general region and the location of these study areas are shown on the map, Figure 1. The study areas were selected with the aim of having them as nearly alike as possible, since it was the effects of the cover differences upon the different deer populations that were being investigated. A discussion of these three chaparral cover types in relation to management has been previously presented (Biswell, *et al.*, 1952). Figures 2-4 illustrate their general appearance.

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A portion of a thesis in Vertebrate Zoology presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the Museum of Vertebrate Zoology, University of California, Berkeley.

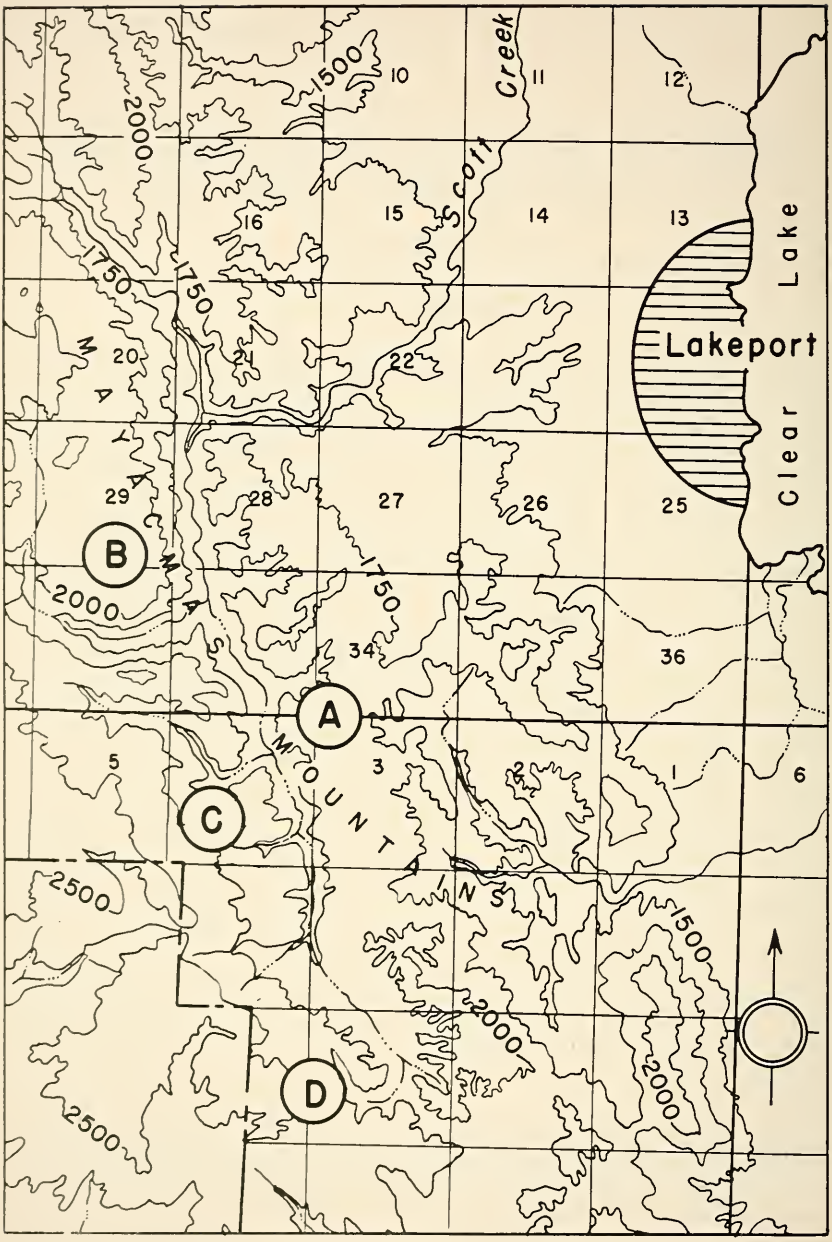

FIGURE 1. Region of study in Lake County, California

FIGURE 2. Opened chaparral of study area A, Lake County, California

FIGURE 3. Eighteen-month-old wildfire burn of study area B, Lake County, California

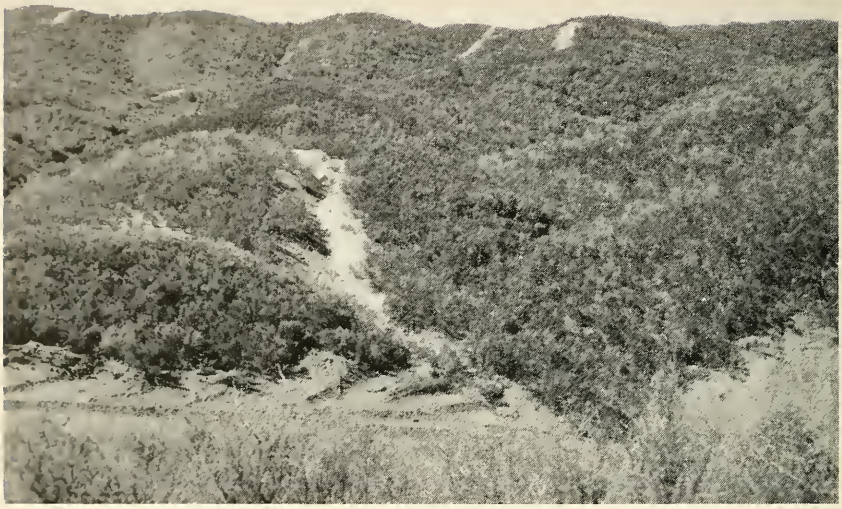

FIGURE 4. Heavy chaparral of study area C. Lake County, California

During the months of February to May, 1950, 38 does, 21 months or older, were collected. Thirteen were from A-type range, 13 were from B-type range and 12 were from C-type range. Because this country is largely roadless the collections involved considerable labor. This was shared by the following Bureau of Game Conservation personnel: Nathan Rogan, then game manager, Merle Sturgeon and Jack Beer, all of the North Coast District, and Alvin Hightower, then of the Disease Investigations Laboratory. In addition, William Longhurst and Herbert Hagen, then of the University of California, helped in the collecting. The autopsy work was done by Merton Rosen, Arthur I. Bischoff and John Azevedo, of the Disease Investigations Laboratory of the Bureau of Game Conservation, and Marietta Voge, of the University of California. Many of the ovary examinations which form part of the basis of this report were made by Raymond Dasmann, of the University of California, under the supervision of O. P. Pearson.

Most of the does collected carried fetuses. These and the ovaries were preserved at the time of autopsy for future examination. In addition, the skull of each doe was saved for age determination. Mature does were classed as medium or old, the criterion being the state of the occlusal surface of the lower first molar. If cusps were present the doe was called medium; if the tooth surface was smooth she was called old.

A study of this material cast light on the following points concerning the does of each area: (1) age at first breeding; (2) prenatal fawn mortality; (3) average fawn production by does of each age class; (4) the date of breeding.

AGE AT FIRST BREEDING

Studies in New York by Cheatum and Severinghaus (1950) on the Virginia white-tailed deer (*O. v. virginianus*) indicate that on good range does often breed at the age of seven months. However, in Utah Robinette

and Gashwiler (1950) found that only 2.2 percent of the Rocky Mountain mule deer (*O. h. hemionus*) fawns would breed at six to eight months of age. In the present study four doe fawns have been examined, three of them being from good range. In none of them was there any evidence to show that their ovaries produced ova during their first fall; a little ovarian activity was indicated by the presence of very small follicles. This suggests that under our conditions the breeding of six-month-old does must be rare or nonexistent. That occasional individuals might breed at this early age is indicated by the records of five black-tailed does which at the age of about one year gave birth to fawns. (Rampont, 1926; Shantz, 1943.)

It is generally thought that black-tailed does first breed at about 17 months of age. All yearling (18-23 months old) does taken in this collection showed considerable ovarian activity. However, not all of them were pregnant. Two yearling does were taken in A-type (opened brush) range; each carried one embryo. Three yearling does were taken in B-type (wildfire burn) range; two carried one embryo each but the third had none. This third doe showed no evidence of ever having been pregnant. No yearling does were collected in the heavy brush (C).

These findings bear out the common supposition that a doe's first mating usually results in a single fawn. In addition, we see here evidence that not all does breed successfully as yearlings. Utah studies have shown that healthy yearlings produced only 0.57 fawns per doe. About one-quarter of them produced twins; over 40 percent of them did not bear fawns (Robinette and Gashwiler, 1950).

It cannot be assumed that every yearling doe will bear a fawn. Variations between deer herds in this respect could cause major differences in the relative productivities of the herds.

FAWN PRODUCTION OF DOES OF EACH AGE CLASS

The fawn production of a given deer herd cannot be learned by simply shooting a sample of does and counting the fetuses unless the sample contains the same proportion of yearling, medium aged and old does as is found in the herd. In practice, a sample is apt to be very light in yearlings. This is because the collectors, to avoid collecting fawns, tend to shoot the full grown animals.

In the region where this study took place the proportion of yearling does in a herd in the late winter may be most accurately determined by a herd composition count made following the preceding rut. In these counts the medium and old does are lumped as adults. In order to derive the relative proportions of does in the medium and old class it has been assumed that these two age classes appear in the collection in the same proportion as they occur in the herd. The proportion of these three age classes of does is derived for three study areas in Table I.

Having broken down the doe herd of each area into its three component age-classes, we must now discover the fawn production of each class. For does which were pregnant when collected it is easy to derive the average number of fetuses per doe. However, some of the does in this collection had already dropped their fawns. Only by studying their ovaries could one discover how many fawns each had produced.

TABLE 1

The Derivation of the Percent of Does in Each of Three Age Classes on Three Chaparral Cover Types, 1950

	Area A (opened brush)	Area B (1948 wildfire)	Area D (mature brush)
Percentage of breeding doe population made up of 18-23 month old ♀ ♀ according to 1949 herd composition count	26	33	27
Percentage of does over two years old in each of two classes, medium and old, based on proportions taken in 1950 spring doe collection	medium 64 old 36	medium 70 old 30	medium 64 old 36
	100	100	100
Percentage of doe population made up respectively of yearling, medium and old does (based on above)	yearling 26 medium 47 old 27	yearling 33 medium 47 old 20	yearling 27 medium 46 old 26
	100	100	100

When a doe comes into heat and her ovaries discharge one or two ova, the ruptured follicles from which these ova came are then filled by enlarged cells and so form solid bodies called corpora lutea. If the ova are not fertilized the corpora lutea begin degeneration after 14 to 15 days. On the other hand, if the ova are fertilized the corpora lutea persist throughout the period of gestation and for some months thereafter (Cheatum, 1949). These corpora lutea may easily be seen with the naked eye; if the fresh ovary is sliced with a razor blade each corpus lutem of pregnancy appears as a solid yellow ball.

Since two ova may be shed at the same time, but only one of them fertilized, it is not accurate to regard the total number of corpora lutea as corresponding exactly to the total number of fetuses. It is necessary to compare the total numbers of corpora lutea and fetuses appearing in those does which were pregnant when collected and then apply this ratio, the "fertilization-rate" to those does which had already fawned when

TABLE 2

Fertilization Rates According to Chaparral Cover Type and Doe Age Class

Chaparral cover type	Age class	Total number of animals in class	Total number of corpora in class	Total number of fetuses in class	Fertilization rate
A (opened brush)	Yearling	2	2	2	100
A (opened brush)	Medium	6	11	10	91
A (opened brush)	Old	3	6	5	83
B (1948 wildfire)	Yearling	3	2	2	100
B (1948 wildfire)	Medium	5	9	9	100
B (1948 wildfire)	Old	3	5	4	80
C (heavy brush)	Medium	2	1	1	100
C (heavy brush)	Old	2	3	3	100
			Total 39		Weighted average 94

they were collected. This has been done in Table 2. Thus the term "fertilization-rate" used in Table 2 refers to the proportion of the number of fetuses to the number of corpora lutea. It has been found among the deer herds of New York to vary from 68 to 96 percent (5) and in our deer collection to vary from 80 to 100 percent, with an average of 94 percent.

Evidently 6 percent of all ova shed at the time of successful breeding did not develop into fetuses. These ova were either not fertilized at all, or were fertilized but did not survive.

It is of interest to note that there seems to be some tendency toward a lower fertilization rate among the older does. This means that of the ova which these older does shed, relatively fewer developed successfully into fetuses. In spite of this tendency the old does averaged highest in fawn production on two of the three study areas.

Among the mule deer of Utah it has been found that the fawn production of very old does is lower than that of prime does (Robinette and Gashwiler, 1950). This is not necessarily in conflict with the findings of the present study. Because of the way our age classes have been set up we include in our "old" class some deer which in Utah would be regarded as "prime." This has resulted, in our case, in the masking of the decline in productivity which probably accompanies extreme old age.

Having seen that 94 percent of all the shed ova were fertilized and developed to the point where they were easily recognized by the naked eye, we have next to see whether there was any loss, or abortion, between that point and birth. Altogether 50 fetuses were taken from collected does. Each one was carefully examined. All of them seemed to have been alive and healthy up to the moment of the doe's death. Under our conditions, then, abortion seems not to be an important factor in reducing the fawn crop. This is in agreement with the findings of Robinette and Gashwiler (1950) in the mule deer of Utah; out of 318 fetuses they found only three (0.9 percent) which were abortive.

By applying the data on "fertilization-rate" from Table 2 to the does which had already fawned when they were collected, their fawn production can be calculated. The records of these does are added to the ones for which fawn production was previously determined, to give the fawn production within each of the three age classes on the three areas of different brush condition. These averages are given in Table 3.

TABLE 3

The Fawn Production Within Each of Three Age Classes on Three Chaparral Cover Types

Chaparral cover type	Number of does	Age class	Total number of fetuses	Average number of fetuses per doe
(A) Opened brush	2	Yearling	2	1.00
(A) Opened brush	7	Medium	11	1.57
(A) Opened brush	4	Old	7	1.75
(B) Wildfire burn	3	Yearling	2	0.66
(B) Wildfire burn	7	Medium	10	1.43
(B) Wildfire burn	3	Old	4	1.33
(C) Mature brush	8	Medium	7	0.88
(C) Mature brush	4	Old	4	1.00

It may be recalled that no yearling does were collected in the mature brush (C) area. Since the productivity of the medium and old does in this area is lower than that of similar does from the other areas, it seems probable that the productivity of yearling does in the mature brush is lower than the productivity of yearling does in the other areas. Therefore I shall assume an average of "less-than-0.66" fawns per doe as the production of the yearling does in the heavy brush.

The average number of fawns per doe, from Table 3, may be multiplied by the percent of breeding does in each age class, from Table 1, to give the productivity of that class. This is done in Table 4.

TABLE 4

Average Fawn Production of Breeding Does on Three Chaparral Cover Types

Chaparral cover type	Age class	Percent of breeding does in this age class		Average number of fetuses per doe in this age class		Fawn production of this age class
(A) Opened brush	Yearling	26	×	1.00	=	26.0
(A) Opened brush	Medium	47	×	1.57	=	73.8
(A) Opened brush	Old	27	×	1.75	=	47.2
						147.0 fawns per 100 breeding does
(B) Wildfire burn	Yearling	33	×	0.66	=	21.8
(B) Wildfire burn	Medium	47	×	1.43	=	67.2
(B) Wildfire burn	Old	20	×	1.33	=	26.6
						115.6 fawns per 100 breeding does
				Less than		Less than
(C) Mature brush	Yearling	27	×	0.66	=	17.8
(C) Mature brush	Medium	46	×	0.88	=	40.5
(C) Mature brush	Old	26	×	1.00	=	26.0
						less than 84.3 fawns per 100 breeding does

Table 4 indicates that fawn production is highest in the opened brush (147 per 100 breeding does), intermediate in the wildfire burn (115.6 per 100 breeding does), and lowest in the mature brush (less than 84.3 per 100 breeding does).

DATING THE RUT

Each fetus was aged by means of Armstrong's key (1950). Since this key employs combinations of developmental characters, such as appearance of hair, pigment spots, eyelashes, etc., it is sometimes not possible to age a fetus precisely; in such a case it may be said that the fetus is within a certain range of ages. The midpoint of each such range was taken as the true fetus age. The age of each fetus may be subtracted from the date of collection to give the date of conception. So far as can be determined

the does in all three study areas bred at about the same time. The peak of conception for 1949 was about the last week of October and the first two weeks of November. The dates of conception for all three areas are combined in Figure 5.

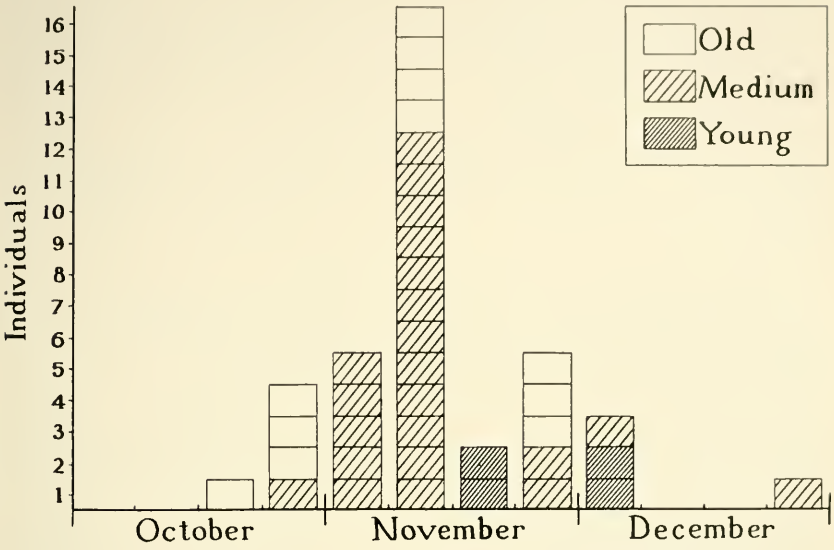

FIGURE 5. The time of breeding (1949) for 37 black-tailed does

From Figure 5 it is evident that yearling does bred later than the average of older does. Also the medium aged does tended to breed at the peak of the rut, while the old does formed the most erratic class, breeding both early and late. The observation that yearlings tend to breed late is commonly made among livestock. In New York (Cheatum and Morton, 1946), where fawns often breed, it has been found that their average breeding date falls about a month later than that of the older does.

DISCUSSION

The evidence here reported points to the conclusion that the three groups of deer under study had different reproductive rates. Since each group of deer was from a different chaparral cover type, it is logical to inquire whether the differences in vegetative cover might not account for the differences in productivity. To clarify the relationships between cover, nutrition and reproduction it is necessary to investigate deer diets and the nutritional values of these diets. Such a study is now under way.

SUMMARY

This report is based on a collection of does made on three contrasting chaparral cover types in Lake County, California, during the months of February, March, April and May, 1950. These cover types were: (A) opened brush (interspersed with herbaceous cover); (B) a 1948 wildfire burn; (C) mature brush. It was found that these deer probably

rarely or never breed as fawns, but commonly first breed as yearlings (at about 17 months). On some ranges not all yearlings breed. Ovary studies showed a "fertilization-rate" of 94 percent. No evidence of prenatal fawn mortality was found. The rates of fawn production were found to be: (A) yearlings, 100 percent; medium-aged does, 157 percent; old does, 175 percent; (B) yearlings, 66 percent; medium-aged does, 143 percent; old does, 133 percent; (C) yearlings (none collected), assumed to be less than 66 percent; medium-aged does, 88 percent; old does, 100 percent. The total productivity of the breeding doe herds was found to be: (A) 147 percent; (B) 115.6 percent; (C) less than 84.3 percent. The peak of conception was found to be the last week of October and the first two weeks of November. The yearlings bred late, the medium-aged does toward the center of the period and old does bred both early and late.

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A POSSIBLE METHOD OF INCREASING WESTERN MOUNTAIN MAHOGANY ON GAME RANGES[1]

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Western mountain mahogany (*Cercocarpus betuloides*) is one of the better browse plants in California, and is cropped readily by deer, sheep, and cattle. This shrub or small tree is scattered in the foothills and mountains at elevations between 500 and 4,000 feet throughout California west of the main Sierra crest. It may be five to eight feet high with spreading branches, or it may form a small tree up to 20 feet high (Jepson, 1925). Western mountain mahogany is one of the main browse species for deer in the regions of the north Coast ranges, the south Coast ranges, the west slope Sierra, and Southern California (Longhurst, Leopold, and Dasmann, 1952). In most areas a greater abundance of this species would be desirable for deer browse and it seems the plant should be increased if possible, especially at the expense of some of the lesser browsed species such as the manzanitas.

Observations and limited measurements made in the foothills of Madera County indicate how western mountain mahogany might be increased in abundance. A few scattered trees of this species were heavily laden with ripe seeds just prior to a control burn of brush on July 17, 1949. The trees were 14 to 16 feet high on a north-facing slope. The fire, burning up the slope, was intense enough to kill the trees and other shrubs, but it did not destroy the seeds on the trees. Three days after the fire the soil in this area was densely covered with mahogany seeds.

Early in the summer of 1950 a large number of mountain mahogany seedlings were found in the area, in some places as many as six or seven per square foot. Many of these survived the summer drought period.

On July 20, 1951, two years after the control burn, the seedlings on four plots were counted. Each plot had a radius of nine feet. There were 12, 21, 49 and 248 seedlings on these plots, with an average of one two-year-old seedling per three square feet. A majority of the seedlings appeared healthy, with maximum heights in the plots between six and 12 inches. The net result was a great increase in western mountain mahogany on this north-facing slope.

Inspections of several late summer wildfire burns in Madera County and elsewhere, over a period of four years, revealed no seedlings of western mountain mahogany while seedlings of many other shrubs occurred in great abundance. It is probable that the seeds will not survive intense summer fires and that they may not remain viable after lying in the duff for long periods of time. The seeds of western mountain

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FIGURE 1. Twig from western mountoin mahogany laden with ripe seeds. The live twig was eight inches long.

mahogany have a soft coat, unlike those of many other shrubs. Rodents may eat many of the seeds.

In the absence of fire a few seedlings emerge each year in the vicinity of old plants but many of them die the first summer after germination as a result of severe plant competition. Nevertheless, this is the principal way in which the plant increases in abundance.

Western mountain mahogany sprouts vigorously after a fire. On summer ranges the new sprouts may be browsed so heavily that some of the plants are killed. On winter ranges, however, utilization may not be particularly heavy or damaging because the shrub is largely deciduous and most of the leaves have fallen.

Based on the above observations, it would appear that controlled fires might be used in some instances to increase the abundance of western mountain mahogany. If this is attempted the firing should be restricted to years of heavy seed crop, when the seeds are nearly ripe and before they fall. The ideal fire seems to be one intense enough to kill the mountain mahogany trees and other shrubs but not so severe as to injure the seeds on the trees.

These results are part of the investigations being carried on cooperatively between the University of California and the California Department of Fish and Game with funds provided by Federal Aid in Wildlife Restoration Act, Pittman-Robertson Research Project California W-31-R.

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PROGRESS REPORT ON A STUDY OF THE KELP BASS, *PARALABRAX CLATHRATUS*[1]

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INTRODUCTION

Five species of fish are particularly important to ocean anglers in Southern California. These are, in the probable order of desirability, albacore (*Thunnus germo*), yellowtail (*Seriola dorsalis*), white seabass (*Cynoscion nobilis*), barracuda (*Sphyraena argentea*), and the kelp bass (*Paralabrax clathratus*). The kelp bass, though not the most desirable, is probably the most important of the game fish in Southern California, because it is available during the entire spring to fall fishing season. This small fish is excellent eating and has fine fighting qualities. More kelp bass are landed by the extensive sportfishing fleet than albacore, yellowtail and white seabass combined.

Currently, the department is conducting extensive studies of the albacore and yellowtail. The white seabass and barracuda have been the objects of moderate studies in the past. The kelp bass, however, had received limited attention. Consequently, as part of the departmental over-all program to benefit marine recreational fishing, it was selected as the species most in need of comprehensive life history study.

The work upon which this report is based was started in 1950. It has consisted largely of a tagging program from which information on growth, migration and spawning activities has been gathered. In addition, the catch of bass per angler each year has been determined from the daily records maintained by sport boat operators. While it is still too early to draw conclusions, it seems wise to present these preliminary results because of the widespread interest of sportsmen in the kelp bass fishery and in this investigation.

There are three species of *Paralabrax* which are lumped together on the daily catch records. The kelp bass is by far the most important. However, the average sportsman does not distinguish between it and the sand bass (*P. nebulifer*). The spotted bass (*P. maculatofasciatus*), the third species, is an inhabitant of the bays and lagoons and is uncommon in the angler's bag. Except for the tables giving records of fish tagged and recovered, this report deals with the kelp bass alone.

Many of the authors of manuals dealing with marine sportfishing in Southern California have devoted some space to the kelp bass: one of the interesting features is the increasing importance of the species. In 1912, Holder wrote that the kelp bass is a "small fish to be caught in unlimited quantities . . . though to the yellowtail or white sea bass angler it is considered a nuisance." In 1930, Thomas referred to the kelp bass

[1] Submitted for publication November, 1952.

". . . affords much pleasure to those who do not care to venture far to sea." These examples trace in a popular sense the transition from a "nuisance" to a "pleasure." In recent years, the kelp bass has provided more fish per sport boat angler than any other species. However, it is very doubtful that the average weight of the fish this day would be half that of the kelp bass in 1912.

CATCH RECORDS

All boat operators who take paying passengers fishing are required to keep records of their catch. Figure 1 is a graphic picture of the total kelp bass catch during May and June for the years 1936-1951 as indicated by the daily catch records of the many sport fishing boats that

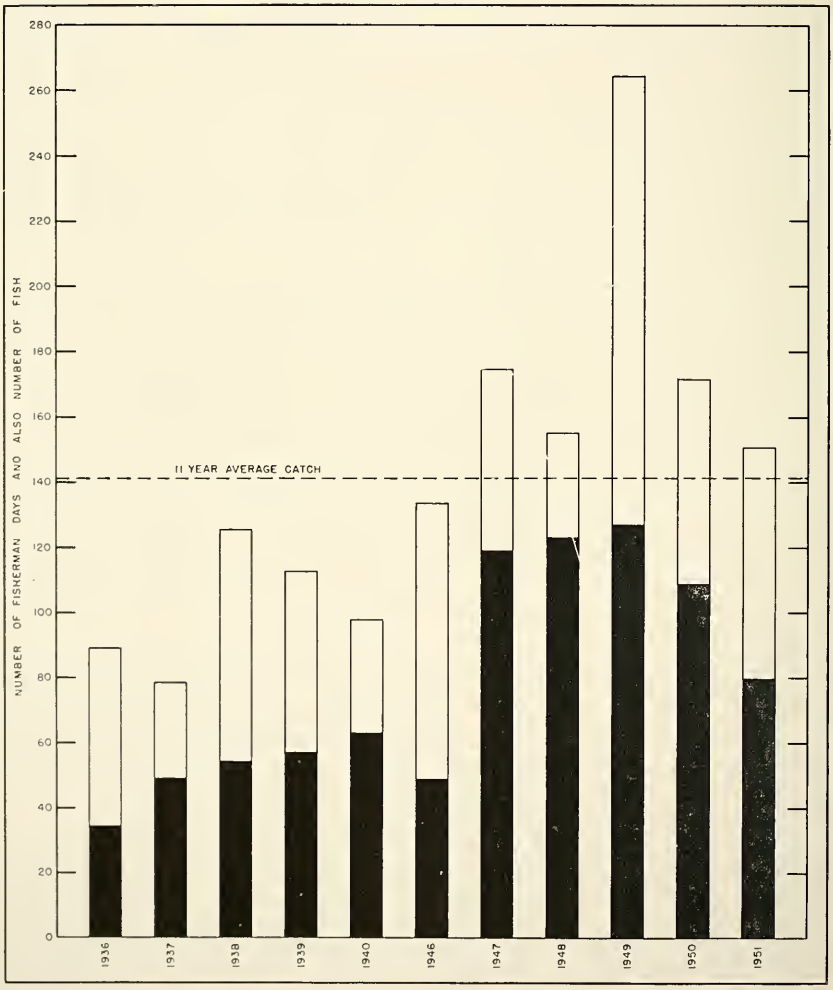

FIGURE 1. Number of *Paralabrax* landed by recreational fishermen, Los Angeles and Orange Counties, May and June only. The horizontal line is the 11-year catch average. Number of fisherman-days indicated by shaded areas. (Numbers are in thousands.)

operate in Southern California. The lower part of each bar indicates the number of fisherman-days involved in the catch for the two months. These two months were selected because at this time sportsmen are most consistently fishing for kelp bass. In other months bass fishing is often affected by occurrences of albacore and other species which are sought in preference to kelp bass.

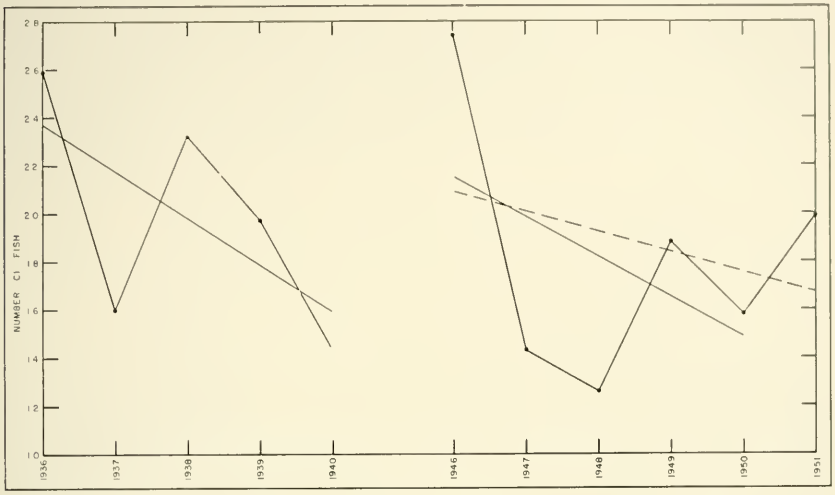

FIGURE 2. *Paralabrax* catch per angler-day, Los Angeles and Orange Counties, May and June only. The trend lines are fitted by the least squares method.

Figure 2 interprets the trend of the kelp bass fishery in terms of fish per angler-day. There are many factors that determine the trend, which over a long period of time, tend to balance out. No data were available during the war period. The trend lines are calculated from the data gathered from a wide area, from Point Dume above Malibu Beach to a point several miles south of San Clemente and from the islands of Santa Catalina and San Clemente. Catch trends from limited areas vary considerably. The slopes of the lines for the periods 1936-1940 and 1946-1950 are very similar and indicate a rapid decline. For the latter time interval, however, this downward slope results from the high return in 1946 immediately following the curtailment of sport fishing during the war years. A line fitted to the years 1946-1951 has a lessened decline and if a line were fitted to the records for 1947-1951 there would be an upward trend. Presumably the stocks of bass accumulated on the fishing grounds between 1940 and 1946 because of lessened fishing effort. These were quickly reduced in numbers but have held their own since 1947 with indications of a slight recovery. As indicated in the following discussion not all grounds have been fished with equal intensity. Fishing effort on local grounds varies from season to season and the upward trend in return may result from concentration of fishing on less exploited localities. A more detailed analysis of catch records, now in progress, should give more accurate information about the abundance of bass stocks on the many fishing grounds.

SIZE OF FISH ON DIFFERENT FISHING GROUNDS

On the fishing grounds that are readily accessible to the large number of party boats in Southern California a reduction in the length and weight of the kelp bass taken by angling has been evident. On some of the very old fishing grounds, kelp bass have all but disappeared from the angler's bag. In other areas, such as the coastal section between Laguna Beach and Oceanside, exploitation of an intense nature has started since the end of the war. At the beginning of this exploitation, the kelp bass were largely of the size known as "bull" bass which can be compared to a "lunker" when speaking of freshwater black bass. Following one or two seasons of intensive fishing in this area, "bull" bass were far less common, and the smaller bass maintained the fishery. This trend has continued until, at the present time, bass less than 11 inches in length comprise 75 percent of the catch. San Clemente Island fishing offers a similar example of the sharp decline in size of the kelp bass. The length frequency distributions of bass, caught by hook and line, at five well separated areas (Figure 5) suggests that the number of large kelp bass are closely related to fishing effort. For instance, the Santa Cruz Island fishery has been exploited by several sportfishing boats operating out of Port Hueneme. These boats do not operate daily, and the fishing season is not as long as the season farther south. The bass at Santa Cruz Island are large by the sportsmen's standard, averaging $15\frac{1}{2}$ inches total length. At San Clemente Island, a fishing grounds that has been quite popular following the war, the kelp bass now approximate 14 inches in total length. San Clemente Island is accessible to boats operating out of Los Angeles Harbor, Long Beach, and Newport Beach. A further comparison of the length frequency distributions of Santa Cruz Island fish with those from San Clemente Island shows that Santa Cruz Island has a greater reservoir of large bass, and that the percentage of each size group is more in balance. The highest mode for San Clemente Island occurs at a point slightly above 12 inches. For Santa Cruz Island, the highest mode occurs at approximately $14\frac{1}{2}$ inches with two additional modes of nearly the same strength at 16 and $18\frac{1}{2}$ inches.

At Santa Catalina Island, for the years 1950 and 1952, length frequency distributions differed widely from those at both San Clemente and Santa Cruz Islands. Kelp bass at Santa Catalina Island have been the object of a continuing fishery for several decades. The shoreline to a depth of 60 feet is well populated with bass, some localities more heavily than others. However, bass 12 inches or longer form less than one-third of the catch. Contrast this with Santa Cruz Island and San Clemente Island where 9 out of 10 bass exceed 12 inches in length. Occasionally, kelp bass over 18 inches total length are taken at Santa Catalina Island, but this is uncommon. The extensive Santa Catalina shoreline with its numerous bays and inlets provides cover for a portion of the bass population. An area less fortunate in protective cover would have even fewer large bass.

The fishing grounds near the mainland town of San Clemente offer a good example of an area that does not provide ample escape cover. These grounds have been heavily exploited since 1946, and the length frequency distribution of the 429 fish tagged there reflect this exploitation. The mode is located at 9.5 inches, dangerously close to the point at which the kelp bass reaches first maturity. There seems to be no reservoir of large

fish, and the steep ascending curve would indicate that small kelp bass, just beginning to enter the sport fishery, form a substantial part of the catch. The San Clemente fishing grounds include those off San Onofre and Las Flores. The boats that operate in this area are based at Newport Beach and at San Clemente.

Fish from a long, dense bed of kelp between La Jolla and Point Loma, principally known as the La Jolla kelp beds, present a length frequency distribution with a higher proportion of large bass than off the town of San Clemente. There are at least two basic reasons for this. The La Jolla beds are fished by boats from San Diego, but mostly as a second choice location, the Coronado Islands being preferred. Secondly, the extent of the kelp beds offers protection to the fish as well as being an inhibiting factor to the passage of small boats.

TABLE 1

Number of Kelp Bass Caught by Size—Hook and Line Fish Only

Area	Size in inches					
	6-8	8-9	9-10	10-11	11-12	12 plus
Santa Catalina Island, 1950	24	47	79	87	48	117
Santa Catalina Island, 1952	8	84	106	95	84	148
Santa Cruz Island, 1950	0	0	0	1	7	150
San Clemente Island, 1950	0	4	2	14	14	198
San Clemente (Town), 1950	2	34	117	124	70	32
La Jolla, 1950	5	12	37	83	81	123

TABLE 2

Percentage of kelp Bass Caught by Size—Hook and Line Fish Only

Area	Size in inches					
	6-8	8-9	9-10	10-11	11-12	12 plus
Santa Catalina Island, 1950	5.97	11.69	19.65	21.64	11.94	29.10
Santa Catalina Island, 1952	1.52	16.00	20.19	18.09	16.00	28.19
Santa Cruz Island, 1950	0	0	0	.63	4.43	94.3
San Clemente Island, 1950	0	1.72	.86	6.03	6.03	85.34
San Clemente (Town), 1950	.52	8.97	30.87	32.71	18.46	8.44
La Jolla, 1950	1.46	3.51	10.85	24.34	23.75	36.07

Tables 1 and 2 present a convenient breakdown of the length frequency distributions from the five areas under discussion. These tables permit comparison of one area with another, particularly on a percentage basis. They are also valuable in determining the result of a limitation of catch (size limits), if any such limitation were to be instituted. These tables are based on hook and line caught fish only.

TAGGING

Localities

To determine the amount of movement, kelp bass have been tagged extensively. Tagging operations during 1950 and 1951 were spread from the Channel Islands and Point Dume to San Diego in California waters. Tagging also took place in Baja California, mostly from the research vessels operated by the Department of Fish and Game. During the 1952 season, tagging was concentrated at Santa Catalina Island and at La Jolla on the mainland. A sprinkling of fish was released in Mexico. During the three seasons concerned in this report, a total of 3,980 bass was tagged and released over a large area of the Southern California seacoast. In Mexico, 192 bass were tagged and released. Figures 3 and 4 show the number and the approximate locations of the tagged fish in both of these large areas.

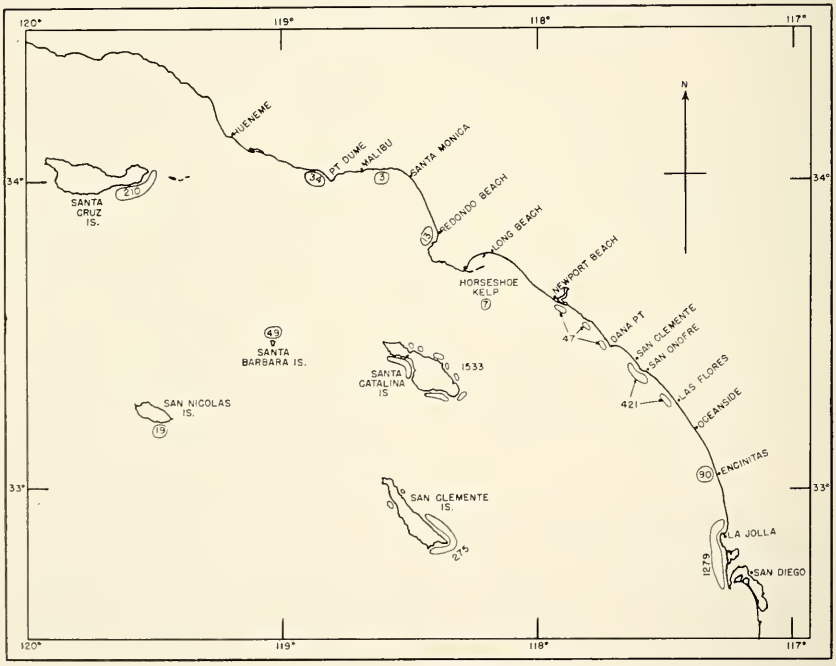

FIGURE 3. Distribution of 3,980 tagged kelp bass in Southern California; fish were tagged during the 1950, 1951 and 1952 seasons

Recovery Rates

Kelp bass were captured for tagging by hook and line, and also by trapping. The tags were attached to the fish with silver wire, stainless steel wire and by monofilament nylon. The recovery rate of bass caught by hook and line is slightly better than that of trap caught fish. Recoveries of bass tagged with nylon tend to be higher than are the returns of bass tagged with either silver or stainless steel.

FIGURE 4. Distribution of 192 tagged kelp bass in Baja California

Table 3 presents the number of fish tagged and the number returned by area. Table 4 is derived from the rate of tag recovery by month. Table 5 represents the number of bass tagged by species, and the recovery by species. Over half of the 506 recoveries, kelp bass and sand bass, were received within the first month and 75 percent were made within the first 60 days. The rapidly declining rate of return indicates quite strongly that there is a tag loss of some proportion. At the same time, the rapid rate of return also indicates a heavy fishing mortality in the areas where tagging took place. On the San Clemente-Las Flores fishing grounds, there was a total tag recovery of 26 percent despite apparent tag loss. This high return correlates with the small number of large bass in the same area. Nineteen percent of the bass tagged at San Clemente Island during 1950 were recovered. There has been no attempt to tag bass here during 1952. However, if an appreciable number of kelp bass were tagged

during 1952, it is very doubtful that the tag recovery would have approached 19 percent. The explanation of this statement lies in the fact that the runs of barracuda, yellowtail and albacore were of large proportions on local grounds during 1952 and the long voyage to the island was unnecessary.

TABLE 3

Releases and Recoveries of Tagged Kelp Bass, 1950-1952—California Only

Area	Number released				Number recovered			
	1950	1951	1952	Total	1950	1951	1952	Total
Santa Cruz Island	93	117	—	210	1	—	—	1
Santa Barbara Island	49	—	—	49	2	1	—	3
Point Dume-Malibu	22	15	—	37	—	1	—	1
Santa Monica Bay	9	4	—	13	2	1	—	3
San Nicolas Island	—	19	—	19	—	—	—	—
Santa Catalina Island	381	67	1,085	1,533	58	13	142	213
Horseshoe Kelp	1	6	—	7	1	—	—	1
Newport Beach-Dana Point	13	30	4	47	10	3	—	13
San Clemente-Las Flores	310	108	3	421	74	36	1	111
San Clemente Island	235	37	3	275	43	10	—	53
Encinitas	90	—	—	90	13	1	—	14
La Jolla-Point Loma	311	13	955	1,279	42	1	34	77
Totals	1,514	416	2,050	3,980	246	67	177	490

TABLE 4

Recoveries of Tagged Kelp and Sand Bass From California and Baja California

	Time out in months													
	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	22–23
Number returned*	258	123	47	24	5	2	1	0	2	4	3	6	1	1
Percent returned	54	26	10	5	1	.4	.2	—	.4	.8	.6	1.3	.2	.2

* An additional 29 fish were returned without information as to the date of recapture.

TABLE 5

Releases and Recaptures by Species

	California and Coronado Island		South of Coronado Islands		
	Kelp bass	Sand bass	Kelp bass	Sand bass	Spotted bass
Number marked	3,980	26	192	215	21
Number returned	490	3	10	3	—
Percent returned	12.3	11.5	5.2	1.4	—

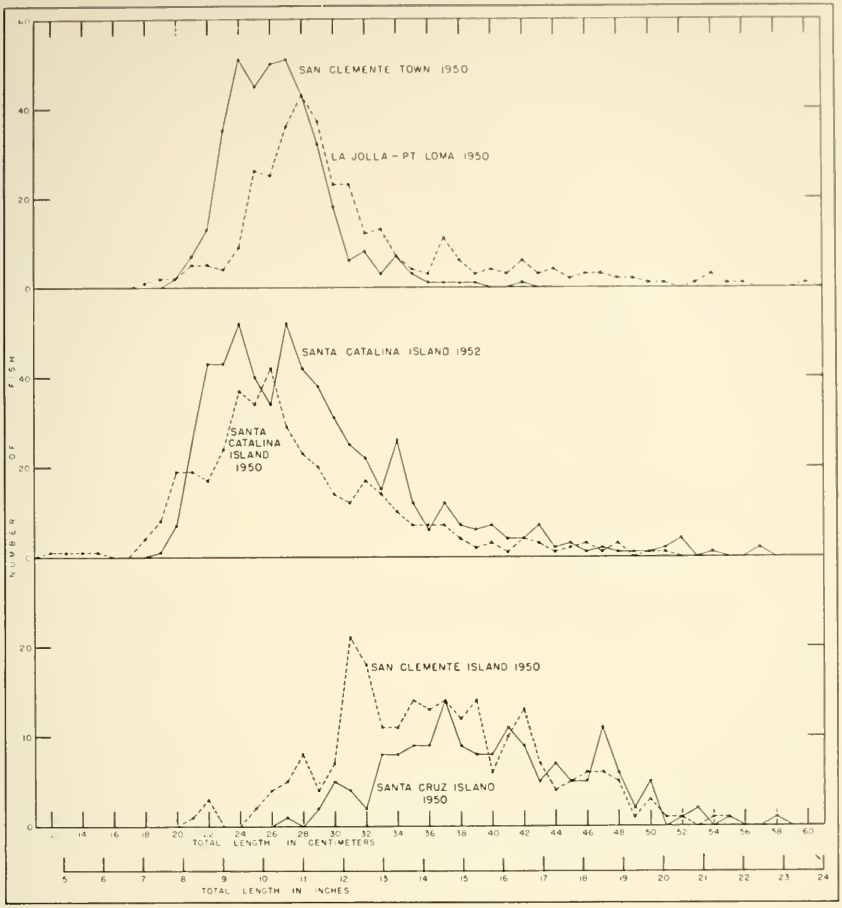

FIGURE 5. Kelp bass length frequency distribution from five of the principal fishing grounds

The tag recovery rate of 14 percent at Santa Catalina Island indicates a fairly heavy effort. This island constantly supports considerable fishing effort. A large proportion of the yellowtail and barracuda taken during 1952 were caught there. Most of the sport fishing fleet that fishes Santa Catalina Island will, as a matter of course, make its way to the island hoping that barracuda and yellowtail will be there. If they are not, there are always kelp bass, with the chance that white sea bass may be taken.

Tag recovery at the La Jolla kelp beds amounted to a total of 6 percent. This recovery was a combination of fish that were caught by hook and line fishing and by trapping. The hook and line fish were tagged at intervals between Point Loma and Bird Rock, La Jolla. The trapped bass were tagged and released principally at La Jolla Cove, a few near Bird Rock.

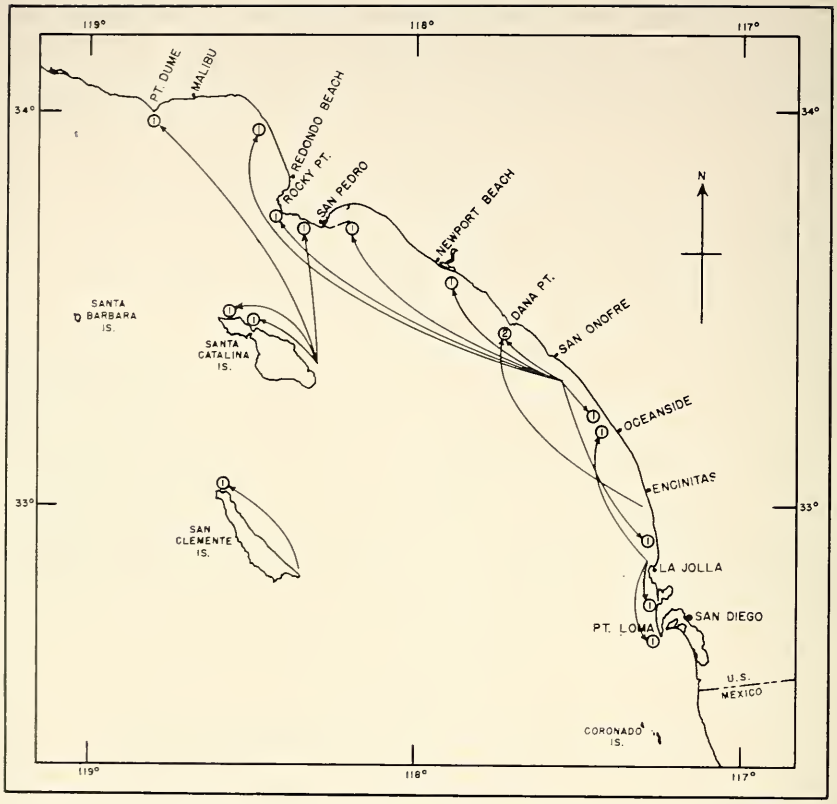

FIGURE 6. Recovery locations. The circled numbers indicate kelp bass migrating five miles or more. The base of the arrows show original tagging locations.

MOVEMENT

Figure 6 shows the movements of 16 kelp bass that equalled or exceeded a distance of five miles. An additional 23 fish moved from a few hundred yards up to four miles. One bass recovered at Guadalupe Island, Baja California, traveled approximately 17 miles. Twenty-eight fish were returned with no data as to movement. A second small block of fish was recovered with data that were either incorrect or could not be verified. Over 400 of the bass recovered, both in Mexico and California, showed no movement.

The results of tag recovery, combined with the striking differences in the length frequency distributions, strongly suggests that the kelp bass fishery is based on a series of independent populations. This belief is further strengthened by the observations of many boat captains in the sport fishing fleet. These men have noted that specific fishing holes can be, and are often, depleted to the point that minnow-size bass are the rule. The recovery of such a depleted ground would depend upon the growth of the small fish in the area, with the possibility of an occasional migrant from another area.

GROWTH

The growth of kelp bass is based upon summer growth data collected from 40 fish that were at liberty from 16 to 133 days following tagging. The growth data were arranged to determine growth rate following a modification of the method advanced by Walford (1946), Figure 7. To estimate growth rates a 60-day interval was chosen. For the 40 fish the length at time of release and of recovery was available. The amount of growth of each fish was divided by the number of days at liberty to obtain the average daily growth rate. This daily average was then multiplied by 60 to estimate the growth over a 60-day interval.

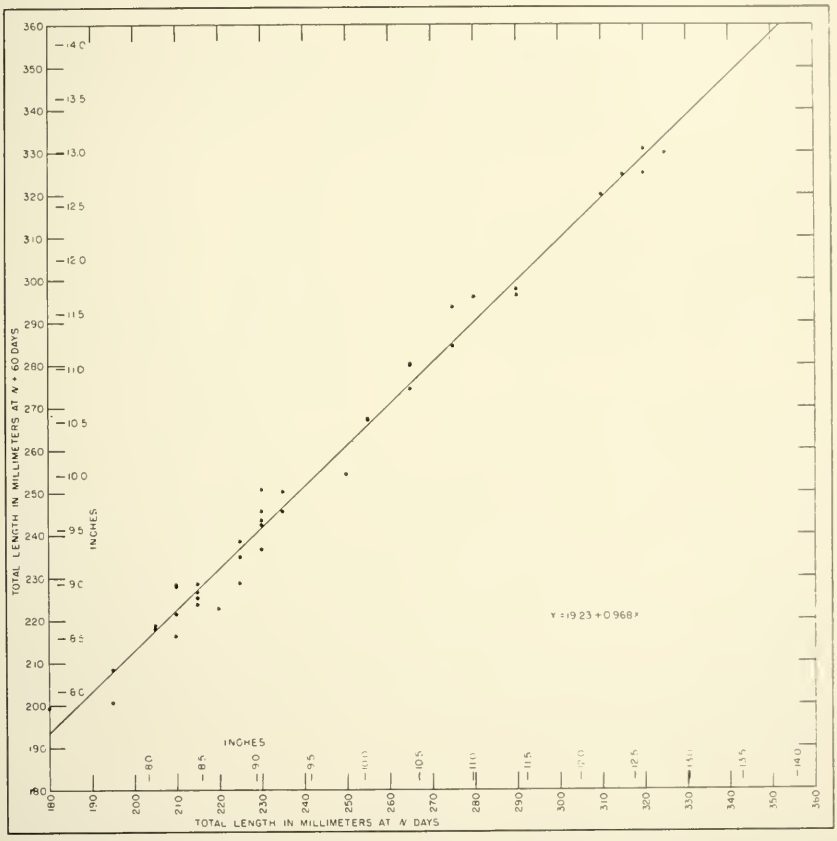

FIGURE 7. Probable growth of the kelp bass, calculated by 60-day growth units. Trend line fitted by method of least squares.

On Figure 7, the horizontal axis represents the length in millimeters at the time of tagging. The vertical axis is the length of the bass 60 days following tagging.

Growth reaches a theoretical maximum at 641 mm. or 25.2 inches. This theoretical maximum agrees closely with the observations in the field. Kelp bass, 615 mm. in length, have been tagged at two widely separated

locations. There have been many reports of larger fish. Growth of a hypothetical eight-inch kelp bass would be as follows:

Month	*Length, inches*	*Increment, inches*
March	8	
May	8.52	.52
July	9.04	.52
September	9.52	.48
November	10.	.48
January	10.44	.44
March	10.88	.44
	Growth = 2.9	in 1 year

However, it is very doubtful that the summer growth rate prevails for the entire year. If 20 percent of the total growth for the year were deducted to allow for decreased growth in the winter, the increment would then be about 2.3 inches for the eight-inch fish in a period of one year.

As a second example of the expected growth increment, the hypothetical growth of a 12-inch bass is presented.

Month	*Length, inches*	*Increment, inches*
March	12.	
May	12.4	.40
July	12.76	.36
September	13.12	.36
November	13.44	.32
January	13.76	.32
March	14.04	.28
	Growth = 2.04	in 1 year

Again deducting 20 percent for decreased winter growth, the increment becomes 1.64 inches.

The theoretical growth rate may shed light on the length frequency distributions that possess two or more distinct modes. For an example, where a mode occurs at eight inches, there may also be a second mode at approximately 10.5 inches. The growth of a bass eight inches in length, is computed to be approximately 2.9 inches in one year, according to Figure 7. The actual growth, as previously pointed out, would be a smaller figure. Thus, the distance between the two modes in the example and the calculated growth of a bass for one year are approximately the same. Unfortunately, polymodal length frequencies have not been encountered that would allow a comparison of three or more consecutive modes with growth over a period of two years or more.

MATURITY

Clark (1933) published an article which included field observations on maturity studies from which the following has been extracted:

"On May 12, fish of both species [*P. clathratus* and *P. nebulifer*] were examined and showed little evidence of the onset of spawning. On May 26, all the larger kelp bass were maturing but the smaller ones were not . . . . On June 2 and 9, both rock [sand] and kelp bass were found in ripe condition . . . . Again on July 14, rock and kelp bass were found completely mature and ready to spawn. The next observation, made on August 8, showed that both species were still spawning. A few fish examined on September 2 appeared to be spent. From these scattered

TABLE 6

Maturity Data for Kelp Bass

Month	Total length in millimeters													
	201-225		226-250		251-275		276-300		301-325		326-350		351-600	
	Number examined	Percent mature	Number examined	Percent mature	Number examined	Percent mature	Number examined	Percent mature	Number examined	Pereent mature	Number examined	Percent mature	Number examined	Percent mature
April			1	0			1	0	3	0	2	50	8	25
May			2	0	15	12	17	76	16	100	6	50	21	81
June	5	100	3	66	6	83	8	100	3	100	7	100	10	100
July	47	21	52	73	46	98	45	100	27	100	23	100	36	100
August					9	100	8	100	10	100	9	100	6	100
September-October	2	0	3	33	6	83	5	60	1	0	2	100	1	100

observations we would conclude that both rock [sand] and kelp bass spawn during the summer months of June, July and August . . . .

"Presumably the average size at first maturity for the kelp bass is about 25 cm., or 10 inches."

Table 6 is arranged from data gathered during 1950 and 1952. In general, the larger fish show evidence of some stage of maturity as early as April. Bass between 201 to 225 mm. are beginning to show signs of maturity in June, and one out of five of the sample of 47 fish taken in July are maturing. In the next size group, from 226-250 mm., three out of four bass are in some stage of maturity during July. All bass larger than 250 mm. would be approximately 100 percent mature by July. In general, the findings of the maturity studies substantiate the conclusions by Clark. However, some bass, less than 25 cm. were found to be maturing.

From the length frequencies of bass taken from heavily fished areas such as Santa Catalina Island, and the town of San Clemente, it is obvious that an appreciable percentage of the fish in the catch have not reached maturity.

TAGGING METHODS

All the bass were tagged with Petersen disks. The disks were laminated with printing on the center layer and protective transparent layers on front and back. Two types were used:

1. 1950 and part of 1951: cellulose acetate disks, 9/16-inch diameter x .030-inch thick.
2. Balance of 1951 and 1952: cellulose nitrate disks, $\frac{1}{2}$-inch x .040-inch. This change was made as a result of experiments which showed that cellulose nitrate was superior to cellulose acetate (Calhoun et al., 1951).

Three materials were used to attach Petersen disks:

1. 1950 and some in 1952: pure silver, medium hard temper pins, .040-inch diameter.
2. 1951: type 302, soft temper stainless steel pins .032-inch diameter.
3. 1952: monofilament nylon leader material, 20-pound test, diameter about .023-inch but varies according to manufacturer.

Other materials used included pointed-nose pliers, hypodermic needles for inserting the wire or nylon through the fish, a measuring device, recording sheets and, for the nylon leader method, a plastic spacing device.

A tagging trip was first arranged with a boat owner. The Southern Council of Conservation Clubs was then contacted and it in turn found the required number of fishermen among its member clubs. At the appointed day and hour, the various sportsmen, Department of Fish and Game personnel, and others assembled at the landing place prepared to go fishing. Bait was then taken aboard and the skipper of the boat set his course for the fishing grounds. Hooks and leaders, usually 1/0 or 2/0 hooks, were given to all fishermen. Upon reaching the first spot to be fished, all hands would start fishing with a gusto that filled an observer with confidence. On the early season trips, more often than not, fishing

FIGURE 8. Tagging kelp bass

was poor with only an occasional fish being caught. However, the procedure went principally as follows: The fish was unhooked and placed in the trough-like container with a built-in measuring rule. The total length of the fish was read to the tip of the upper caudal lobe. On some fish a sample of the scales was taken to be used for age determinations at a later date. Actual tagging was accomplished with the aid of a hypodermic needle with the syringe head removed. A numbered disk was threaded on a pin or on a nylon filament and the pin in turn was inserted in the lumen of the needle. The needle was passed through the back of the fish just below the junction of the spinous and soft dorsal fins and removed from the other side, leaving the tag and pin in place. A second disk was threaded over the pin, the finishing knot was tied, and the fish returned to the water. The greater number of fish disappeared quickly.

On several trips, fishing became so successful that the tagger was forced to cut the wire leaders in order to save the time required to unhook the fish. In other instances, the fish swallowed the bait and hook, making it virtually impossible to release the fish without severe injury. In such cases the leader was cut at a point close to the mouth. Several fish that were freed with the hook deeply imbedded in the throat have been returned after months of freedom. In no case could any evidence of the hook still be found.

The data recorded included in addition to total length, the number of the disk, a descriptive note on where the fish was caught and released, usually both the same, a remark if scales were taken, and the date and name of the boat from which the catch was made.

During 1952, only a small number of the bass tagged were taken on sport fishing boats. Most of the fish were caught my means of wire traps. These traps were of two principal types. The most successful was a cylinder 4 feet in diameter and 22 inches high, built of $\frac{7}{16}$-inch round steel stock. It was equipped with a large top-opening trap door and two fykes. Hexagonal wire poultry netting, usually one inch, was used to cover the frame and form the fykes or funnels. From the top of the trap, a three-strand bridle was secured, leading to the central pull rope. A wooden or cork float was used on the top free end of the pull rope to mark location of the trap. A small cylindrical bait box was fastened inside of the trap at a point about half way between the inside openings of the fykes. A second type trap, much lighter and more difficult to manufacture, was a cylinder about 22 inches in diameter and 36 inches tall. At one end was a flat trap door, and at the other, a built-in fyke. On the internal opening of the fyke, stiff wires were affixed, pointing in toward the center of the trap and the suspended bait box. The wires did not interfere with ingress, but are supposed to offer some deterrent to escape. Bait used varied from fish entrails to ground fresh and salted sardines and anchovies. No particular advantage was observed for any specific bait.

FIGURE 9. Large fish trap; upside down view

Traps usually fished the best during the mid-day hours. Each trap was pulled at 45-minute to 2-hour intervals. Nothing was gained by leaving the trap for the longer period. When a trap was pulled to the surface, the fish were immediately emptied into a large container of water so that the tagging could proceed smoothly as successive traps were pulled and the bass dumped into the receivers.

A cotton glove with a soft leather palm on the left hand helped to prevent the fish slipping from a light grasp and also cut down on the number of uncomfortable stabs received from the spines on the dorsal and anal fins. The time required to handle a fish from the moment it was lifted from the receiver until it was released varied according to circumstances. Thirty seconds was fast time. In the general state of confusion that abounds when fishing is good, a bass may be dropped or slip away from the tagger, the needle may be jabbed into the thumb instead of the fish, or other disconcerting events may stretch the tagging time to several minutes. Also fish were frequently landed too fast for the tagging crew to handle. The fish were then dropped in the bait tank, held on the hook in the water, held in the hands of the fisherman or sometimes just left on the deck to await being marked. Fortunately the tagger was usually able to keep up so that the fish were returned to the water promptly. There is no indication that handling bass or keeping them out of water for a minute or two has any harmful effects. The authors and many others have concluded that these bass are very hardy fish.

A great deal of time is saved in the tagging operation by insuring that as each pin and disk are used, a new pin and disk are placed in the needle ready for the next fish. This detail is attended to by the recorder. Sufficient tags and pins for each trip were mounted in numerical sequence in advance.

When tagging was initiated, signs were posted along the Southern California coast at every landing or place where fishermen congregate. These signs directed the fisherman to give all of the necessary information on the catch of a tagged fish and also requested that the entire fish be returned to the Department of Fish and Game with the tags intact. Each fisherman who turned in a marked fish with adequate data has received a wallet-size plastic commendation card engraved with a brief history of the fish and also the name of the fisherman. The actual tags are imbedded in the plastic. In addition, prizes for lucky numbered fish were donated by various interested organizations, chiefly the Southern California Sporting Goods Dealers Association. Drawings were held on the Tom Harmon television show.

SUMMARY

The kelp bass (*Paralabrax clathratus*) is one of the most important species to Southern California marine anglers. Catch analyses and length frequency studies show that this fish is probably decreasing in abundance and in size. As a result, a kelp bass tagging program and life history study was initiated in 1950.

At the close of the 1952 season, 4,172 bass had been tagged in Southern California and Mexican waters. There were 500 recoveries, most of which were recaptured within 60 days after release. Percentage returns, by area, ran as high as 26 percent. The great majority of bass recoveries

were from virtually the same place where they were released. Only 16 fish showed movements of five miles or more. The kelp bass fishery is probably based on a series of independent populations.

Hypothetical growth rates, based on the summer growth data from 40 tagged fish, showed an annual increment of 2.3 inches for an eight-inch bass and 1.64 inches for a 12-inch bass.

The average size at first maturity was found to be approximately 10 inches, which substantiates the work of Clark (1932).

The main spawning months are May through August.

Petersen disks were used to tag all bass, but considerable experimenting was done with various materials both for the disks and for the pins.

During 1950 and 1951 most of the bass were taken by hook and line through the cooperation of sportfishing boat owners and sportsmen. The 1952 fish were nearly all captured in traps.

ACKNOWLEDGMENTS

This study was a cooperative venture. It was made possible through the aid of many people who are interested in marine recreational fishing. We particularly wish to thank the many sportfishing boat operators who donated tagging trips; the bait haulers who gave us bait; the anglers who helped to catch the fish; the Superior Tackle Company, who supplied the hooks and leaders; Mr. O. R. Armstrong of the Southern California Sporting Goods Dealers Association, who arranged for prizes and the drawings on the Tom Harmon television program; Mr. Conrad Limbaugh and the Scripps Institution of Oceanography. We also wish to acknowledge the help of the Bureau of Patrol, Department of Fish and Game. Many of the members of the California State Fisheries Laboratory made pertinent suggestions and participated in the field work. To all of the above, we offer our sincere appreciation.

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AQUARIUM TESTS OF TAGS ON STRIPED BASS[1]

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Anglers for striped bass (*Roccus saxatilis*) have increased sharply in California (Calhoun, 1950) and the upward trend is expected to continue. This situation raises questions about the adequacy of present regulations such as length of season, bag limit and minimum size. These cannot be answered sensibly without knowing roughly how many of the available fish are being caught annually.

One objective of the California Striped Bass Investigation has been to obtain an index of the present rate of harvest by means of a tagging program. It soon became apparent that a better tag than those used previously on bass (Clark, 1934, 1936; Merriman, 1941) was necessary. Certain metals and plastics commonly employed in the past were found to have serious shortcomings (Calhoun, Fry and Hughes, 1951).

Extensive tagging of wild fish of many kinds (Rounsefell and Kask, 1945) has not ordinarily thrown much light on the relative merits of different kinds of tags or different locations on the fish.

Aquarium tests, for all their obvious limitations, can reveal a great deal along these lines.

This report summarizes the results of recent aquarium experiments to discover satisfactory materials for Petersen disk tags and to observe the individual behavior of various kinds of tags in different locations on striped bass over fairly long periods of time.

The cooperation of Dr. E. S. Herald, Curator of Steinhart Aquarium, is gratefully acknowledged. He made a large, salt-water display tank available indefinitely for this project. The tagged fish, shown in Figure 1, became a popular public exhibit. We are also indebted to Messrs. Robert Dempster, Fred Herms, and Walter Schneebeli of the aquarium staff, who cared for the fish. The stimulating suggestions of Mr. Park B. Hyde and his assistance in fabricating special tags were particularly helpful.

PETERSEN DISK TAGS

The Petersen disk tag still appears to be the most satisfactory type of tag for general use on striped bass. It consists of two buttons, one at each end of a wire passing through some part of the fish. Examples can be seen on the tails and beneath the dorsal fins of the fish in Figure 1. The knot commonly tied at each end of the wire is shown in Figure 3a.

[1] Submitted for publication November, 1952.

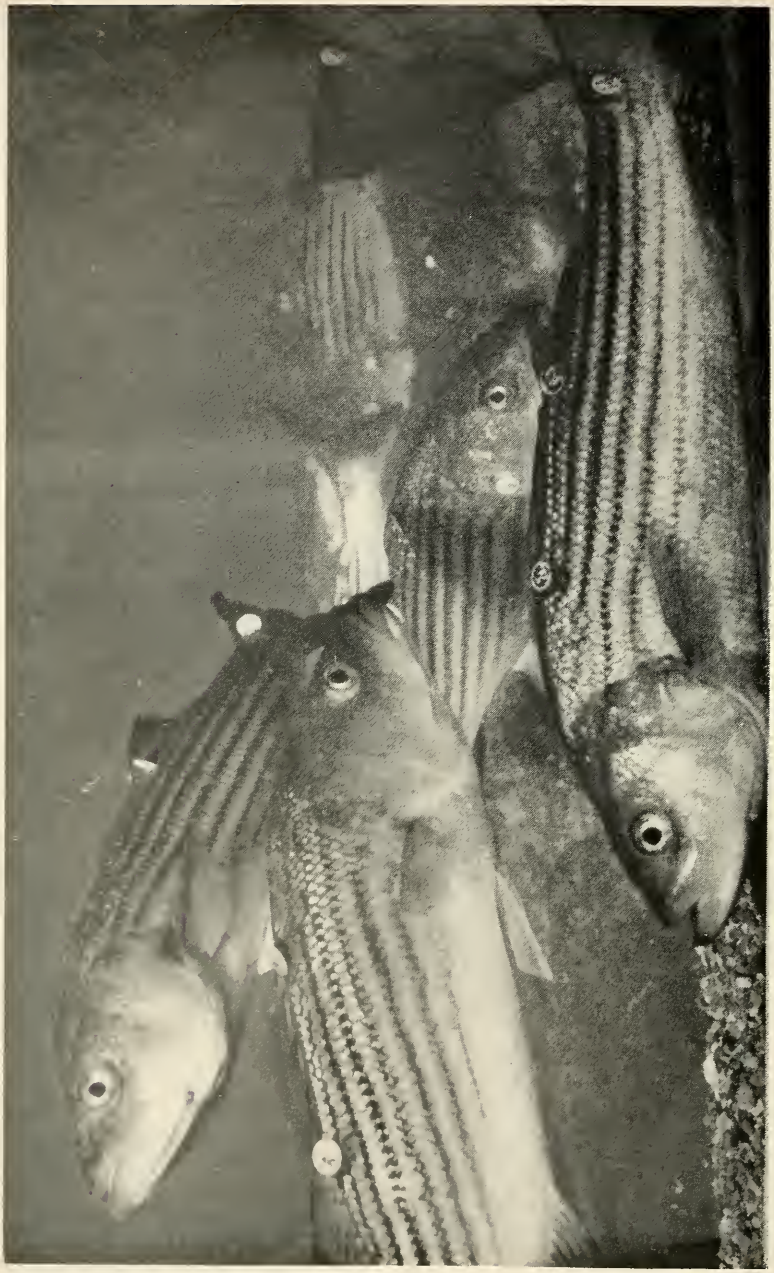

FIGURE 1. Tagged striped bass in display tank at Steinhart Aquarium

Metals and Plastics

Recent studies have been aimed primarily at discovering some combination of metal wire and Petersen disks which would last indefinitely on large, active fish in salt and brackish water. Nickel, silver, and monel have not been tested further, since they are clearly unsatisfactory (Calhoun, Fry and Hughes, 1951). Work with stainless steel has continued. Type 316 wire showed no evidence of corrosion or weakening even after two years in the aquarium. Similarly, type 302 wires were uniformly in perfect condition after 14 months, when all of the test fish died as the result of an accident. Further evaluation must await the results of more prolonged tests with wild fish.

Testing of tantalum has also continued. No corrosion has ever been detected. In one instance, 0.036-inch diameter tantalum has broken in the aquarium after two years and three months on the caudal peduncle of a bass. The knotted end of the wire parted and the disk came off during a routine examination. Failures have also been noted in returns of 0.032-inch diameter wire after about one year on the caudal pedunceles of wild bass.

Tantalum still has promise, however, particularly if it can be incorporated into a tag which is immobilized in some way, thereby eliminating the working of the metal and permitting the tissues to grow to the wire. This is discussed more fully later.

No adherence of tissue to the tantalum wire of Petersen tags occurred in aquarium experiments lasting several years. Movement of disks and wire as the fish swam apparently prevented it.

Earlier conclusions about plastics have been confirmed. Cellulose nitrate disks 0.045-inch thick are proving entirely satisfactory. Thick cellulose acetate disks (0.045-inch) used on wild striped bass are being returned in a generally satisfactory condition after 18 months, although they are obviously not as good as nitrate. A disk 0.030-inch thick wore down to 0.020 inch during two years on an aquarium bass, and another broke and dropped off, further confirming the inferiority of acetate.

Position of Petersen Disk Tags

Disk tags were tested on the caudal peduncle, under the first and second dorsals, and on the opercle. In general, except in the case of the opercle, the numbers of tests were too small and aquarium conditions were not rigorous enough to give very clear-cut results. The tests are nevertheless of considerable interest and they will be summarized briefly, for valuable inferences can be drawn from them.

In one experiment six disks on the caudal peduncle were compared with 11 under the dorsal fins, using 0.036 tantalum wire for all. Fish about 15 inches long were used. After two years and three months, when the fish all died, five of the six tags under the anterior end of the first dorsal were as good as new. The sixth had been lost earlier through cracking of a vinylite disk, which was found on the bottom of the tank. The five under the second dorsal were all still in place, although only one was in really good condition. There was a great deal of slack in the wires of two, and the remaining two had migrated upward a considerable distance and would soon have been shed.

These results indicate that the first dorsal position is superior to the second.

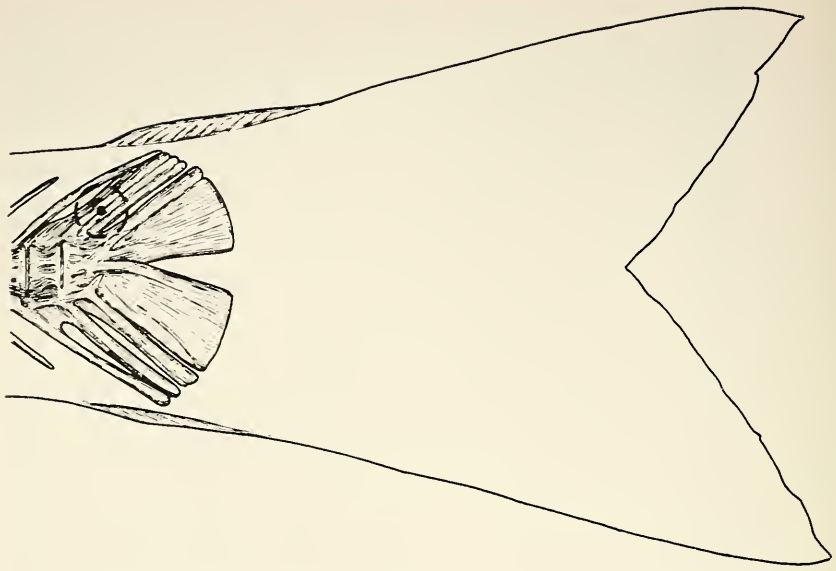

FIGURE 2. Location of Petersen disk tag on caudal peduncle of striped bass

The six caudal peduncle tags were located as shown in Figure 2. Three were lost the first year: one through a cracked disk, and the others possibly for the same reason or through the death of the fish, although this is uncertain. It was not until later that fish were tagged so they could be recognized individually without draining the tank, and the cause of some early losses is uncertain. Of the three still in place after two years and three months, the wire on one broke in handling, although the tag was otherwise satisfactory; and the other two had worked back about one-half inch and were quite loose. This broken tantalum wire was the same one mentioned earlier.

In a companion experiment begun a month later with these same fish, 12 tags were placed under the first and second dorsal, using vinylite disks and stainless steel (Type 316, 0.036 inch diameter). One of the six under the first dorsal was lost early in the experiment, possibly through a cracked disk or the death of a fish. The other five were still on after two years and two months. Three were in satisfactory condition, but the other two had migrated up almost into the base of the fin and would soon have been shed.

Four of the six under the second dorsal were still in place at the end of the experiment. One of those lost was observed about half way up through the fin after one year. At the next inspection, a month later, it had been shed. The second was shed after 18 months. Of the four remaining after two years and two months, two were satisfactory, one was very loose, and one was at the very base of the fin and would soon have been shed. Here again there is at least an implication that the first dorsal location is superior to the second dorsal.

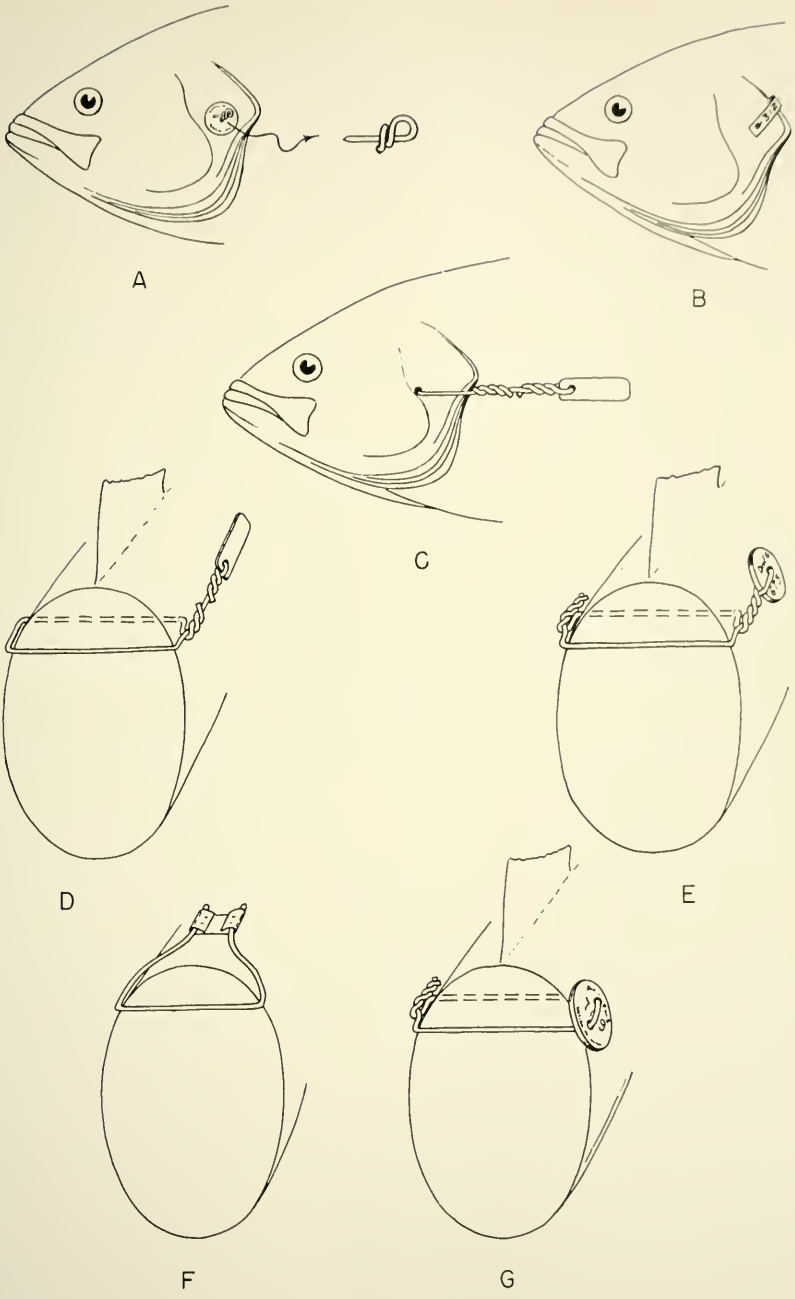

FIGURE 3. Diagrams of tags tested: (a) Petersen disk on opercle, (b) strap tag on opercle, (c) Atkins tag on opercle, (d) and (e) Atkins tags on back, (f) Oregon type tag and (g) staple tag

The performance of these dorsal tags with stainless steel wire was poor compared with the tantalum ones discussed earlier. This probably resulted partly from the difficulty of tying a good knot in the relatively thick (0.036 inch diameter) stainless steel, making a satisfactory application of the tag difficult to attain.

There is little doubt that shedding of a similar sort will occur even more rapidly on wild fish.

Unfortunately positions on the caudal peduncle were not available for this second experiment with stainless steel because old caudal tags from preceding experiments remained on so well. Six were still in a satisfactory state after more than three years.

Another experiment was begun about one year after those just discussed. The test fish ranged from about 10 to 20 inches in fork length. Thirteen Petersen disks were tested on the caudal peduncle. All disks were cellulose nitrate (diameter one-half inch, thickness 0.045) and all wires were 0.032 inch diameter. Soft-temper tantalum and the medium-soft and dead-soft temper type 302 stainless steels were used in about equal numbers with no apparent differences in behavior. Twelve of these caudal tags were still on and in a reasonably satisfactory condition after 14 months. Nine were on small bass initially 10 to 12 inches long, and the other four were on larger fish from 16 to 19 inches. Most of the tags appeared to have migrated backward about one-fourth inch during the 14 months, leaving well-healed scars to mark their passage. The thirteenth tag had been shed after one year and two weeks. It was on a small fish 10 inches long. The wire had cut backward and upward until it worked out at the base of the upper caudal rays.

Four disk tags under the first dorsal were included in this same test, using stainless steel wires. Two were in satisfactory condition after 14 months, another was very loose and the fourth was almost up into the dorsal fin itself. These were on medium-sized bass from 12 to 16 inches long.

A large number of tags were placed on cheeks in this same experiment, as shown in Figure 3a, with most interesting results. Such tags have been used widely (Rounsefell and Kask, 1945). The rivets used on the cheeks of shad (Cable, 1950) proved infeasible because of the thinness of the opercular bones of bass. There was too much space between the rivet head which goes inside the cheek and the disk which goes on the outside. Worse, they did not permit any adjustment of this distance for large and small fish. The usual 0.032-inch wires were accordingly resorted to for these tests. They were headed into pins to avoid a knot on the inside which might injure the gills.

These tags were a great disappointment. Sizable holes were worn in the cheek rapidly, even in the case of large bass with thick opercular bones. Only 8 of 19 tags remained on for 14 months, and all of these were in an unsatisfactory condition. One had made a hole large enough to pull the whole tag through readily, and another had made one almost as large. The others had migrated down and back for considerable distances: a full inch in three cases, three-fourths inch in two cases, and one-half inch in two cases. Two fish died after about three months, and the tags had already worn large, irregular holes around the pins in the cheeks of both. The other nine opercular disk tags were shed: two after less than two months, one after six months, two after 10 months, and four after

about one year. The rate of shedding would undoubtedly have been even more rapid in wild fish.

It is obvious that opercles of striped bass undergo too much continual movement for this type of tag, which soon cuts its way through the hard, thin opercular bone. While rivets might have been slightly better, because of their larger diameter, there is little doubt that they would have behaved in a similar manner. The cutting of large holes in the cheek has also been reported in experiments with Petersen tags on the opercles of haddock (Rounsefell, 1942).

The caudal peduncle location for Petersen tags was adopted early for use on striped bass in the field because it appeared best in early aquarium experiments, and because it was thought that more growth would be possible and less entanglement in gill nets would occur than under the dorsal fins.

Great care is exercised in field tagging to place the wire in the exact spot shown in Figure 2, where it is surrounded by bone.[1] It was hoped that this would retard shedding.

In the aquarium, tags in this position have commonly migrated backward at the rate of about one-fourth inch per year, as already mentioned. It is obvious that they will not stay on in the wild indefinitely, as had been hoped. However, indications are that they will be retained for at least a year on wild bass larger than about 12 inches. Their use is not recommended on smaller fish, however, for even in the aquarium they have tended to work out through the relatively tender tissues.

Aquarium tests have clearly ruled out the opercle and the second dorsal of striped bass for Petersen disks, but some doubt remains about the first dorsal, which may prove equal or possibly superior to the caudal peduncle. The front end of the fish's body undergoes relatively little lateral motion during swimming, compared with the tail, and a tag under the first dorsal will be subject to less movement than one on the caudal peduncle. Moreover, the greater thickness of flesh through which the wire passes will tend to retard migration through the tissues. Further experiments on wild fish will be required to resolve this point.

STRAP TAGS

This type of tag was commercially available only in monel metal, which has corroded so rapidly in previous experiments that it was obviously unsuitable. A few were therefore hand-fabricated from sheet stainless steel 0.020 inch thick. They were placed on the upper edge of the opercle, as shown in Figure 3b. Only one of five remained on after 14 months, and it had cut its way down the edge of the cheek a full inch, deforming it considerably in the process. This type of tag is clearly unsuitable for use on striped bass. Similar results have been reported for Pacific mackerel (Roedel, 1949).

Strap tags on the jaw, so commonly used for fresh-water fish, were not tried on striped bass because of the delicacy of their maxillaries and premaxillaries, and because such tags are believed to interfere too much with normal feeding.

[1] The place is readily located externally. It lies halfway between the lateral line and the top of the caudal peduncle on a vertical line downward from the forward end of the little dorsal ridge in front of the caudal fin.

ATKINS TAGS

A considerable assortment of Atkins tags was also tested. One type consisted of a small plastic blank, roughly one by one-fourth inch, suspended on a 0.015 tantalum wire. Ten of these were placed on the cheek as shown in Figure 3c. Eight were shed within three months, and the remaining two were gone within four. Without exception, the fine wire cut back rapidly through the bone.

This same type of dangler behaved much better when the wire was looped through the back about three-fourths inch beneath a dorsal fin, as shown in Figure 3d. These held up surprisingly well, in view of the thinness and softness of the metal and the amount of movement they underwent. Perhaps the most significant result was the apparent adherence of the tissue of the fish to the tantalum wire in three of eight cases after 14 months, in spite of this considerable motion. The other five showed no such adherence. In all instances the wire on the side away from the dangler had become imbedded and was no longer visible. All of these tags remained on for 14 months, although one of them was on the point of breaking then, as a result of failure of the wire from continual working.

The tag is not recommended for general use, because of the way it moves when the fish swims; preventing immobilization and leading to working of the metal. However, a modification (Figure 3e) has recently been tried on wild catfish (*Ictalurus catus*), using 0.020 diameter tantalum wire, with promising results.

Several other Atkins tags were less satisfactory. Small rectangles of stainless steel crimped onto heavy, braided nylon cord, diagrammed in Figure 3f, were obtained from the Oregon Fish Commission. Five were tried, but unfortunately four of the fish died too soon for an adequate test. The remaining one was on a bass about 20 inches long. The cord was threaded once through the back, well below the first dorsal. At all observations there were extensive raw areas on each side where the nylon entered. The cord worked its way out and was shed within about nine months, leaving a large, conspicuous scar. Shedding would probably have occurred even more quickly on a wild fish of the same size.

Five similar tags fabricated from stainless steel blanks and Saran monofilament plastic were all shed within about two months, presumably because the steel cut the Saran.

STAPLE TAG

This tag, shown in Figure 3g, was developed to embody the desirable features of both the Petersen disk and the tantalum dangler, and to eliminate the undesirable ones. The disk is largely immobilized by the two wires through the heavy muscle tissue of the back, which greatly reduce its freedom to move. Location well forward under the first dorsal where lateral movement of the fish's body is at a minimum may permit the tissues to adhere to the tantalum wire (0.020 inch diameter) and incorporate it as a part of the fish. Use of a single disk may also allow the other side to grow over completely, as happened with tantalum danglers on the back in the aquarium. It is also possible that elimination of one disk will permit much growth before the remaining one becomes completely imbedded. Another apparent advantage is the reduced chance for entanglement of the tag in gill nets, which is often such a serious problem.

Twenty tags of this type were placed on bass in the aquarium just one month before the fish were all lost. No changes of consequence occurred during the month. It will be some time before there will be an opportunity to test them again on striped bass. They are a promising tag worth trying. It must be emphasized, however, that they are unproved, and some unanticipated disadvantage may counterbalance the apparent advantages.

This tag is much like the so-called "Archer" tag (Rounsefell and Kask, 1945, p. 329). However, the latter was usually located on the dorsal or adipose fin, where rapid shedding is to be expected. A great many of the other tags described by Rounsefell and Kask were also in locations which must have led to early shedding.

SUMMARY

Further observations have confirmed the superiority of cellulose nitrate over cellulose acetate and vinylite for Petersen disk tags. Stainless steel tag wires (type 302, diameter 0.032 inches; type 316, diameter, 0.036) have never corroded or broken in salt-water aquarium tests. Tantalum wire (0.036 inch diameter) broke in one instance in the aquarium, after two years and three months on the caudal peduncle. There have been similar failures in returns from wild fish after about a year.

Petersen disk tags were tested on the opercle and caudal peduncle and under the first and second dorsals of striped bass. Those on the cheek were soon shed. The wire cut rapidly through the opercular bones. In general, those under the second dorsal did not remain in place as well as those under the first dorsal or on the caudal peduncle. There was some indication that a location well forward under the anterior end of the first dorsal might be particularly advantageous. Tags on the caudal peduncle stayed on well, but migrated backward about one-quarter inch per year. Some of the dorsal tags also migrated badly, while others remained in place indefinitely. Further field tests will be required to determine the relative merits of the first dorsal and caudal peduncle locations. Well applied tags of suitable materials will usually remain on in both places for several years in the aquarium.

Strap tags and Atkins tags on the cheek were shed rapidly.

Atkins tags on thin tantalum wire looped through the back lasted surprisingly well.

A staple tag well under the first dorsal, using one disk and two tantalum wires through the back and twisted together on the other side, appears promising, although it remains to be tested.

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THE EFFECT OF THE COMMERCIAL CANNING PROCESS UPON PUFFER POISON[1]

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Although puffers, fishes belonging to the family Tetraodontidae, are generally classified as "trash fishes" they have been used as food by native peoples for many centuries. Puffers are widely distributed throughout most warm seas and the range of some species extends into temperate waters. These fishes are known by many vernacular names, *viz.*, blowfish, tambor, rabbitfish, swellfish, swellbelly, swelltoad, blower, jugfish (U. S.), toadfish, toado (Australia), blaser (Dutch East Indies), Ikan buntal (Malaya), tambores (Cuba), botete (Philippines and Latin America), fugu (Japan), etc. In spite of their extensive use for food by native peoples, the roe and other viscera of the puffer are generally considered to be extremely toxic.

The threatened depletion of some of our fisheries resources has stimulated certain organizations to conduct research along lines which will contribute to an increased utilization of our marine resources. A number of fishing companies have been experimenting with the commercial possibilities of "trash fishes." According to Yudkin (1945), *Sphoeroides maculatus* (Bloch and Schneider), the common puffer of the Atlantic coast, began to appear in increasing numbers in the fish markets of northeastern United States about 1943. The market appearance of this fish was of some concern to those who were acquainted with the virulent properties of puffer roe.

Toxicity studies on the roe of *S. maculatus* have been conducted by Yudkin. He found that the roe of the Atlantic puffer contains a poison whose pharmacological properties are similar to those of Japanese tetraodontoxin. Fortunately the toxin, which has a cardio-inhibitor action, is not present in sufficient quantities in *S. maculatus* to be lethal to human beings.

There are about 10 different species of tetraodons inhabiting the waters of western North and Middle America. Some of these species may be considered as candidates for the commercial fish markets of the Pacific Coast. At the present time there is only fragmentary data regarding the toxic properties of the puffers of the tropical Pacific. However, there is considerable information concerning the chemical and pharmacological properties of tetraodontoxin from Japanese puffers but the

[1] This investigation was supported by a research grant from the National Institutes of Health, Public Health Service, and a contract with the Office of Naval Research, Department of the Navy (NONR-205(00)). Submitted for publication September, 1952.

bulk of this work is not readily available to most American researchers. Since it is a well-established fact that tetraodontoxin is not destroyed by ordinary cooking methods it was considered advisable to conduct a series of experiments relative to the effect of the commercial canning process upon the virulence of puffer poison. This is the first of a series of papers which are now in preparation relative to the problem of puffer poisoning.

MEDICAL ASPECTS OF PUFFER POISONING

The potential significance of puffer poisoning can be most readily appreciated by briefly reviewing the situation as it has existed in Japan. Pawlowsky (1927) states that during the period from 1888 to 1909 there were 3,106 known cases of puffer poisoning in Japan, which resulted in 2,090 deaths, an average of about 100 deaths a year. According to Fukuda and Tani (1937), there were 909 deaths resulting from fugu poisoning during the 10 year period from 1927 to 1937 which accounted for 44 percent of the total food poisonings in Japan. Fugu poisoning has been regarded as Japan's most important single cause of food intoxication. Recent reports from the Japanese National Ministry of Welfare and Health (*in litt.*) reveal that during 1949 to 1951 there were 389 reported cases with an over-all mortality rate of 57 percent.

Puffer poisoning usually occurs as a result of ingesting the gonads, liver or intestines. The musculature of most Japanese species are said to be nontoxic (Tani, 1945). But one is not safe in assuming that the flesh of all tropical species are innocuous. Recent tests in our laboratories on the musculature of *Arothron hispidus* (Linnaeus) and *A. meleagris* (Lacépède), common puffers of the central Pacific, indicate that the musculature of these species may at times be violently toxic. This present study will reveal that the musculature of certain Japanese puffer species may also be toxic on occasion.

Japanese scientists have demonstrated that there is considerable fluctuation in the toxicity of oriental puffers. A similar situation has been found to occur in *A. meleagris*. Specimens taken in French Frigate Shoals, Hawaiian Islands, during January, 1950, proved to have nontoxic musculature while those taken at Hull, Phoenix Islands, during July, 1950, were violently toxic. The factors which influence toxicity fluctuation are not known at this time, but apparently there is some relationship to the gonadal activity of the fish. Tani (1945) has shown that the toxicity level is highest during the spawning season of the year, which for most oriental species is during May and June. The gonads begin to enlarge about November and reach their maximum size and weight about February or March. The toxicity level reaches its peak a short time before the spawning season, continues for a few weeks after spawning and then gradually declines.

The symptoms of intoxication generally develop rapidly and consist essentially of numbness and tingling of the lips, tongue and finger-tips, accompanied by dizziness, headache, weakness and dyspnea. Gastrointestinal symptoms such as nausea, vomiting and abdominal pain are usually present. The forementioned symptoms may be accompanied or

followed by additional neurological disturbances which in fatal cases may be very severe, *viz.*, severe ataxia, impairment of speech, convulsions and muscular paralysis. Death results from respiratory paralysis and may occur in less than one hour or up to 20-24 hours. If death does not occur within 24 hours, the chances for the recovery of the patient are considered to be good. Richardson (1861) records two deaths which occurred at the Cape of Good Hope as a result of ingesting the liver of a puffer [*Sp. indet.*, probably *Arothron nigropunctatus* (Bloch and Schneider), or *A. stellatus* (Bloch and Schneider)]. One death occurred in 20 minutes and the other in 17 minutes.

The treatment of tetraodon poisoning is largely symptomatic. There is no known antidote. Injections of epinephrine are believed to be of value (Kimura 1927). However, even with the best medical care the over-all mortality rate is considered to be about 60 percent.

CHEMICAL NATURE OF PUFFER TOXIN

The chemical properties of puffer poison have been studied by a number of Japanese workers, Tahara (1894, 1910), Ishihara (1924), Nagai and Ito (1939), Kanayama (1943), Yokoo (1948, 1950), Hashimoto and Migita (1951) and others, but probably the most complete work is that by Tahara. His work has been well summarized by Yudkin (1944: 12-13) as follows: "Tetrodotoxin [2] exists as a white, hygroscopic powder, very readily soluble in water and insoluble in the ordinary organic solvents. It consists of carbon, hydrogen, oxygen and nitrogen; the provisional chemical formula is assigned as $C_{16}H_{31}NO_{16}$. The substance does not give any of the protein reactions nor is it precipitated by the alkaloidal reagents. The possibility that the poison is a protamine derivative is entirely excluded. The lethal dose with tetrodotoxin obtained by the new method (Tahara 1910) is 4 mg. per kgm. body weight. * * * Other than statements to the effect that tetrodotoxin is neither a protein, an alkaloid, nor a protamine, Tahara does not go into the chemical structure of the poison." Nagai and Ito (1939) have suggested that the poison is probably an acyclic compound. Judging from an exhaustive review of the scientific literature dealing with puffer poison, the exact chemical structure of tetraodontoxin and the source of the poison are still unknown. The reader is referred to the works of Tani (1945), Suehiro (1947), and Kimura (1927), for more complete reviews of the over-all problem.

MATERIALS AND METHODS

The puffers used in this study were obtained from the Central Wholesale Fish Market at Kyobashi, Tokyo, Japan, by Dr. Tokiharu Abe. The specimens were captured along the coast of southern Japan and in the East China Sea during the winter and early spring of 1950-51. The fishes were iced soon after capture, later sharp-frozen and then shipped to our laboratory under refrigeration. The fish were not permitted to thaw until the extracts were prepared.

[2] The designation *tetrodo*toxin (or *tetrodon*toxin as it is sometimes spelled) is derived from the misspelling of the puffer genus, *Tetraodon*. Taxonomists have relegated *Tetrodon* to synonymy but this misspelled term is still deeply entrenched in medical and biochemical literature. We are recommending that the correct spelling of the prefix be used, thus: *tetraodon*toxin and not *tetrodo*toxin (Halstead—in press).

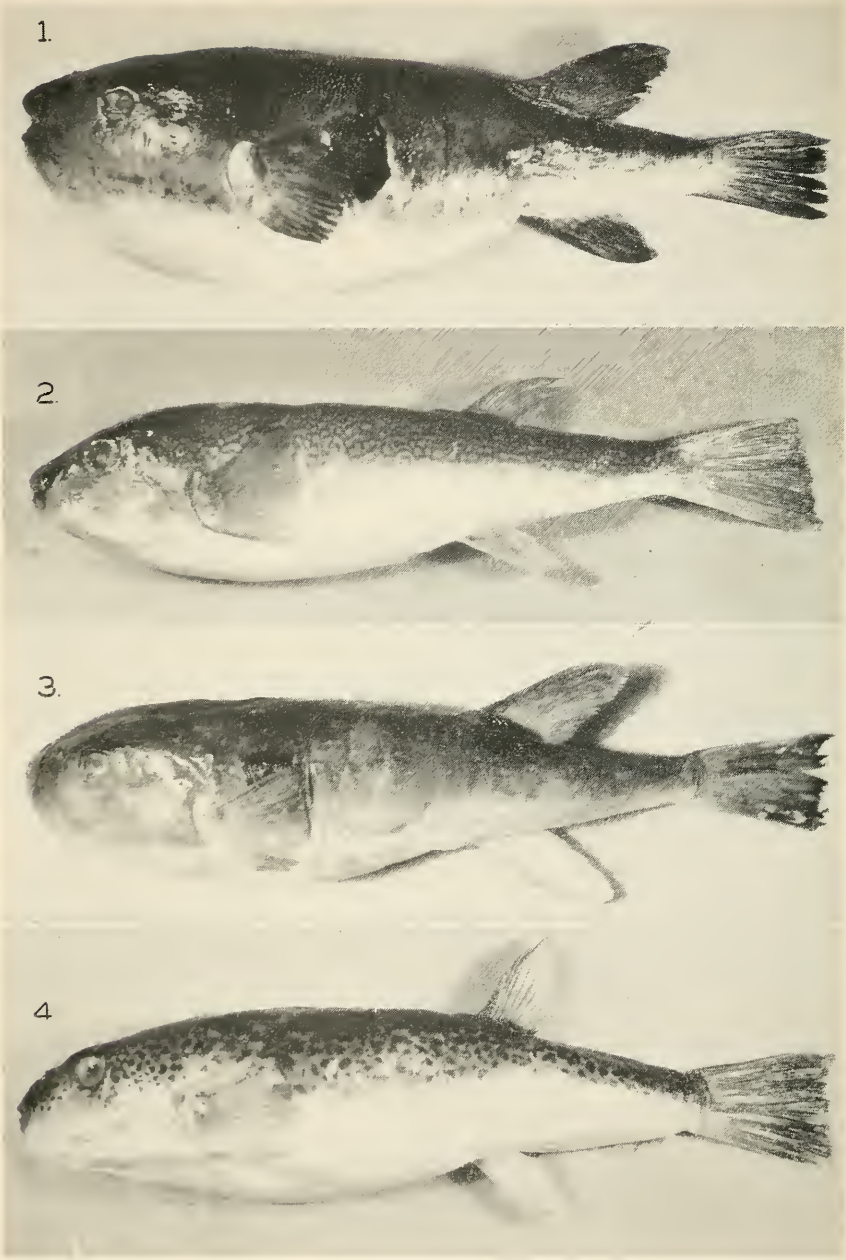

FIGURE 1. (1) *Sphoeroides rubripes chinensis* Abe; (2) *Sphoeroides vermicularis porphyreus* (Temminck and Schlegel); (3) *Sphaeroides vermicularis radiatus* Abe; (4) *Sphoeroides vermicularis vermicularis* (Temminck and Schlegel).

Taxonomic identifications were made with the use of Abe's (1949) critical analyses, "Taxonomic studies on the puffers (Tetraodontidae, Teleostei) from Japan and adjacent regions." The terminology as suggested by Abe have been adopted in this report. Tissue extracts were prepared from the following Japanese puffers (Figure 1):

Sphoeroides rubripes chinensis Abe.
Sphoeroides vermicularis porphyreus (Temminck and Schlegel).
Sphoeroides vermicularis radiatus Abe.
Sphoeroides vermicularis vermicularis (Temminck and Schlegel).

All of the examples examined were mature specimens, but in some instances sexual determination was questionable because some of the fishes were taken during a period of gonadal quiescence.

Tissue extracts were prepared from the musculature, liver, intestines and gonads. Two ml. of distilled water were added for each gram of flesh. The material was then homogenized in a Waring blendor. The homogenate was centrifuged at 2,000 r.p.m. for 25 minutes at about 1,000 "G's." One ml. of the supernatant fluid was injected intraperitoneally into four white laboratory mice of the California Caviary Strain No. 1, weighing 15 to 25 gm. each. In order to determine the effects of the processing upon the virulence of the toxins, samples of each tissue specimen were tested both before and after canning. No mouse was used more than once.

The canning process, which approximated commercial canning procedure, was conducted in the research laboratory of the Van Camp Sea Food Company at Terminal Island, California. The musculature, liver, gonads and intestines were placed in separate commercial one-half pound cans. In some instances cross sections were taken from the entire fish which included both musculature and viscera. For each can of flesh 3.5 gm. of ordinary table salt were added. The open cans were then placed in a steam exhaust at 100 degrees C. for 10 minutes. Water heated to 82.2 degrees C. was then added to fill the can. Lids were placed on the cans and sealed. The cans were next placed in a steam retort under a pressure of 12.5 pounds per square inch at 116.6 degrees C. for 75 minutes. The cans were cooled by immersing them in cold water upon their removal from the retort. All fish samples were processed in the same manner and at the same time. The fish were canned on July 3, 1952, and the cans were opened and tested on July 9th, 10th, 14th, 15th and 17th. There was no correlation observed between the length of time the fish remained in the can and their toxicity. Extracts were prepared immediately upon removal of the tissue samples from the can and were tested upon mice without further delay.

RESULTS

The results of the experiment appear in Table 1.

TABLE 1

Results of Intraperitoneal Injections of Puffer Tissue Extracts Into Mice

Ext. No.	Species	Tissue	Mouse No.	Death Time—min. sec.			
				Before Canning	Toxicity	After Canning	Toxicity
580–1	*S. r. chinensis*	M	1	30:20	S	Ataxic, hypoactive[3]	W
		M	2	29:10	S	" "	W
		M	3	26:15	S	" "	W
		M	4	28:25	S	" "	W
580–2	" "	L	1	01:55	S	" "	W
		L	2	01:30	S	" "	W
		L	3	02:20	S	" "	W
		L	4	01:50	S	" "	W
580–3	" "	G ♂	1	21:50	S	" "	W
		G ♂	2	29:55	S	" "	W
		G ♂	3	about 40 minutes	S	" "	W
		G ♂	4	about 1 hr. 20 min.	M	" "	W
580–4	" "	I	1	03:50	S	Asymptomatic	N
		I	2	04:20	S	"	N
		I	3	05:35	S	"	N
		I	4	04:45	S	"	N
581–1	*S. v. porphyreus*	M	1	02:35	S	Asymptomatic	N
		M	2	02:35	S	"	N
		M	3	02:15	S	"	N
		M	4	02:35	S	"	N
581–2	" "	L	1	01:20	S	"	N
		L	2	01:20	S	"	N
		L	3	01:30	S	"	N
		L	4	01:30	S	"	N
556–1	*S. v. radiatus*	M	1	27:30	S	Asymptomatic	N
		M	2	26:25	S	"	N
		M	3	25:30	S	"	N
		M	4	26:05	S	"	N
556–2	" "	L	1	09:05	S	"	N
		L	2	13:05	S	"	N
		L	3	15:20	S	"	N
		L	4	16:00	S	"	N
557–1	" "	M	1	05:45	S	"	N
		M	2	05:30	S	"	N
		M	3	05:00	S	"	N
		M	4	05:00	S	"	N
557–2	" "	L	1	01:20	S	07:30[3]	S
		L	2	01:30	S	16:50	S
		L	3	01:30	S	08:20	S
		L	4	01:30	S	11:35	S
557–3	" "	G ♀	1	00:50	S	10:20	S
		G ♀	2	00:50	S	10:15	S
		G ♀	3	00:40	S	07:35	S
		G ♀	4	00:45	S	08:40	S
557–4	" "	I	1	02:25	S	Asymptomatic	N
		I	2	02:00	S	"	N
		I	3	02:30	S	"	N
		I	4	02:30	S	"	N

TABLE 1—Continued

Ext. No.	Species	Tissue	Mouse No.	Death Time—min. sec			
				Before Canning	Toxicity	After Canning	Toxicity
551–1	*S. r. vermicularis*	M	1	Asymptomatic	N	Asymptomatic	N
551–2	" "	L	1	"	N	"	N
551–3	" "	G ♀	1	"	N	"	N
552–1	" "	M	1	33:30	S	"	N
		M	2	28:00	S	"	N
		M	3	27:45	S	"	N
		M	4	31:00	S	"	N
552–2	" "	L	1	03:10	S	"	N
		L	2	03:10	S	"	N
		L	3	03:10	S	"	N
		L	4	03:55	S	"	N
560–1	" "	M	1	29:40	S	Ataxic, hypoactive	W
		M	2	Hypoactive, survived	W	" "	W
		M	3	27:30	S	" "	W
		M	4	26:30	S	" "	W
560–2	" "	L	1	05:10	S	" "	W
		L	2	03:40	S	" "	W
		L	3	04:50	S	" "	W
		L	4	03:45	S	" "	W
560–3	" "	G ♀	1	01:10	S	" "	W
		G ♀	2	01:05	S	" "	W
		G ♀	3	01:25	S	" "	W
		G ♀	4	01:05	S	" "	W
562–1	" "	M	1	28:00	S	Asymptomatic	N
		M	2	18:25	S	"	N
		M	3	17:50	S	"	N
		M	4	29:25	S	"	N
562–2	" "	L	1	06:45	S	"	N
		L	2	06:50	S	"	N
		L	3	07:30	S	"	N
		L	4	08:00	S	"	N

Legend for Table 1: M = muscle; L = liver; G = gonads; I = intestine. [3] Juice in can positive but tissue sample negative. N = negative: mouse continues to remain asymptomatic during the maximum test period of 36 hours. W = weakly positive: mouse shows definite symptoms such as lacrimation, diarrhea, ruffling of the hair, hypoactivity, etc., but the animal recovers. M = moderately positive: mouse develops ataxia, hypoactivity, and/or paralysis and dies within a period of 1 to 36 hours. S = strongly positive: mouse develops ataxia, which is usually followed by clonic or tetanic convulsions of varying degrees, paradoxical respiration, respiratory paralysis and death occurs within a few seconds to one hour.

The results appearing in Table 1 seem to indicate that the virulence (based on mouse death time) or toxin concentration and heat lability varies with the species, individual specimen and the organ from which the toxin was obtained. As previously mentioned, Tani (1945) and others have demonstrated that the toxin concentration with the body of the fish varies also with the season of the year. There is also evidence to indicate that a puffer species may be poisonous in one locality and not in another.

Tissue extracts prepared from the liver, gonads and intestines of *Sphoeroides rubripes chinensis*, *S. r. vermicularis* and *S. vermicularis radiatus* were found to be strongly toxic prior to canning but only those samples taken from the liver and gonads of *S. r. radiatus* continued to remain so after canning. However, even in this latter instance it will be noted that the virulence of the toxins were somewhat attenuated as indicated by the increased length of time required to kill the mice. The toxins of *S. r. chinensis* and *S. v. vermicularis* are considerably more heat labile than that of *S. v. radiatus*. In both *S. r. chinensis* and *S. v. radiatus* the intestinal toxins which were found to be strongly positive prior to canning were rendered innocuous by the heating process. If the food-chain

theory is correct, then the chemical properties of puffer toxin are probably modified by the organ system through which the toxin passes.

The four fish specimens of *S. v. vermicularis* which were tested proved to be quite variable. Only one fish was found to yield weakly positive results after the canning process. Extracts No. 551-1, 2, 3 were used as controls. One specimen of *S. v. porphyreus* was tested and the toxin was found to be heat labile.

In analyzing the contents of the can after processing, it was found that the toxin was limited to the liquid fraction. None of the muscle samples were found to be toxic after canning, since tetraodontoxin is water soluble.

Tani (1945) states that "unless one eats a large amount of puffer flesh, a person cannot become intoxicated from eating the musculature of the puffers of Japan, Korea and China." The results obtained in this study reveal that the musculature of the four Japanese puffers under consideration may on occasion be strongly toxic. In the case of *S. v. porphyreus* the virulence of the toxin obtained from the musculature was found to approximate that obtained from the liver.

SUMMARY

1. The threatened depletion of some of our marine resources has stimulated a number of organizations to investigate the commercial possibilities of various trash fishes. Since puffers, which are generally considered to be trash fishes, have recently been introduced on the East Coast as food fishes and may be sold on the West Coast, attention is called to the potential public health significance of these fishes.

2. The most severe forms of puffer intoxication generally occur as the result of ingesting the liver, intestines or gonads. However, the musculature may frequently be violently toxic. Fugu, or puffer poisoning, is accompanied by severe neurological symptoms which may result in the death of the victim by respiratory paralysis. The over-all mortality rate is said to be about 60 percent. There is no known specific antidote for tetraodontoxin.

3. The toxin is not a protein, an alkaloid nor a protamine. Some workers believe it to be an acyclic compound. The provisional formula has been assigned by Tahara, a Japanese investigator, as $C_{16}H_{31}NO_{16}$ but the exact chemical structure of the toxin is unknown.

4. Tissue extracts were prepared from samples of the musculature, liver, gonads and intestines of four common Japanese puffers, *Sphoeroides rubripes chinensis* Abe, and *S. vermicularis porphyreus* (Temminck and Schlegel). Samples of the same specimen were tested both before and after the canning process in order to determine the heat lability of the toxin. The virulence of the extracts obtained from the muscle, liver and gonads of some of the specimens of *S. r. chinensis* and *S. v. vermicularis* was markedly attenuated but not completely destroyed. Extracts from the liver and gonads of *S. v. radiatus* were only slightly affected by the heating process and continued to be strongly positive. In the case of *S. v. porphyreus* and certain specimens of *S. v. chinensis, S. r. radiatus* and *S. v. vermicularis* the toxins were found to be heat labile. Apparently the property of heat lability is subject to a wide

degree of fluctuation. The factors contributing to this situation are not clearly understood at this time.

5. In general, the problem of poisonous fishes will become of increasing public health significance as attempts are made to develop the shore fisheries of the tropical Pacific.

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A PRELIMINARY REPORT OF THE TOXICITY OF THE GULF PUFFER, *SPHOEROIDES ANNULATUS*[1]

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Since "trash fishes" are receiving an increasing amount of attention as potential protein food sources, it was considered advisable to conduct a series of studies relative to the public health significance of poisonous puffers. The work reported in this paper was done preliminary to an extensive investigation of the physiological activity of various tissue extracts from the gulf puffer, *Sphoeroides annulatus* (Jenyns). The physiological studies which are now in progress will be reported at a later date. Only the results dealing with the toxicity experiments will be given at this time. These show that the gulf puffer should not be considered for use (whole, parts, or cleaned) for either human or animal consumption.

The earliest record of poisonous fishes from the Gulf of California is that of Calvijero (1706). In his history of Baja California he mentions the incident of four soldiers who were poisoned by eating the liver of a botete, or puffer, which was captured in the Gulf of California. One of the soldiers died in 30 minutes; another died a short time later; a third, who had chewed the liver without swallowing it, lost consciousness until the following day; the fourth, "who had barely touched it," was sick for several days. This incident is also mentioned by Pellegrin (1899) and Phisalix (1922), who state that the liver and musculature of the botete were commonly used by the natives of Baja California for poisoning stray dogs—a custom which is still practiced in some regions today. These authors state that the puffer eaten was *Tetrodon heraldi* Günther, which is listed by Jordan, Evermann and Clark (1930) as a synonym of *S. annulatus* (Jenyns). Aside from the forementioned references we have been unable to locate any literature relative to the pharmacological properties of the toxin of the gulf puffer.

MATERIALS AND METHODS

Ninety-six specimens of *Sphoeroides annulatus* (Figure 1) were collected by the senior author and Robert Smith by underwater spearing and hook-and-line from Bocochibampo Bay about three miles north of Guaymas, Sonora, Mexico, during June 23-25, 1952. *S. annulatus* ranges

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FIGURE 1. The gulf puffer, *Sphoeroides annulatus* (Jenyns). (from Hiyama)

from San Diego, California, to Mazatlan, Mexico. This species is particularly common along sandy shores and bays throughout the Gulf of California.

The fish were quick-frozen within a few minutes after capture and remained frozen for two to three weeks until the extracts were prepared. Twelve specimens were selected at random from the lot. The weights of the whole fish, liver, and gonads were taken prior to preparation of the tissue extracts. The material was homogenized in a Waring blendor to which two ml. of distilled water were added for each gram of tissue. The homogenate was centrifuged and one ml. of the supernatant fluid injected intraperitoneally into a male white laboratory mouse of the California Caviary Strain No. 1, weighing 17 to 27 gm. (average 20.9 gm.). Four mice were used in testing each extract. Their reactions were observed and recorded. The cessation of all breathing movements was taken as the time of death. The weights and injection results appear in Table 1. A summary of the averages of weights and death times appears in Table 2.

RESULTS AND DISCUSSION

Of the 12 fish tested, none were found to possess toxic muscle, 11 specimens had strongly toxic livers, and four had strongly toxic gonads. If the average death times after injection of liver extract are compared with the weights of the whole livers as percentage of body weight (Table 1), there seems to be no correlation between organ size and toxicity (death time). The average death time for liver extract was 3 minutes and 10 seconds (range 1:20-14:45). Although the data are limited, there is apparently no correlation between gonad size and toxicity. The average death time for gonadal extracts was 13 minutes and 8 seconds (range 2:50-40:45).

The toxic reaction herein referred to consisted of the following symptoms: an initial hyperkinesia followed by a mild ataxia; as the ataxia progressed, dyspnea set in, developed into apnea and death ensued accompanied by moderate to severe clonic convulsions. The heart continued to beat for several minutes after the cessation of breathing. The mechanism of the action of this toxin is being investigated and will be reported at a later date.

In checking over some of our earlier records it was found that one specimen of this species had been collected on April 4, 1951, from San Felipe, Baja California. The fish was handled and extracts prepared in a manner similar to that employed with the Guaymas specimens. Extracts were made of the musculature, liver and intestines. The gonads were too small for testing purposes. The tissue samples weighed about 7 gm. each.

TABLE 1

Fish No.	Weight of fish (gm.)	Tissue	Weight of sample (gm.)	Percent of body weight	Average death time (min.: sec.)	Injection results*
1	437	mus.	11			—
		liv.	13	2.97		—
		gon.	18	4.11		—
2	477	mus.	12			—
		liv.	21	4.40	2:15	†
		gon.	1.5	0.314	4:00	†
3	455	mus.	13			—
		liv.	15	3.29	1:45	†
		gon.	0.5	0.11		—
4	339	mus.	16			—
		liv.	13.5	3.38	15:11	†
		gon.	28	8.25		—
5	387	mus.	13			—
		liv.	19	4.90	2:11	†
		gon.	1	0.25		—
6	291	mus.	10			—
		liv.	15.5	5.32	3:00	†
		gon.	1.25	0.43	20:18	†
7	290	mus.	11			—
		liv.	4.5	1.55	1:30	—
		gon.	1.25	0.43	31:30	†
8	307	mus.	10			—
		liv.	13.25	4.31	1:49	†
		gon.	1	0.33		—
9	275	mus.	10			—
		liv.	11.5	4.18	3:00	†
		gon.	3.25	1.18	4:26	†
10	254	mus.	7			—
		liv.	6.5	2.55	2:11	†
		gon.	1	0.39		—
11	248	mus.	10			—
		liv.	12	4.83	2:52	†
		gon.	6.5	2.62		—
12	676	mus.	11			—
		liv.	26	3.84	2:15	†
		gon.	53.25	7.87		—

* — Asymptomatic.
† Toxic reaction.

TABLE 2

Summary of Averages

Item	Average	Range	Number of items
Fish weight	353.0 gm.	248–676 gm.	12
Liver "	14.22 gm.	4.5–26.0 gm.	12
Gonad "	9.7 gm.	0.5–53.76 gm.	12
Muscle "	11.16 gm.	7.0–13.0 gm.	12
Mouse "	20.9 gm.	17.0–27.0 gm.	144
Liver death time	3:10 min.	1:20–14:45 min.	44 (11 fish)
Gonad death time	13:08 min.	2:50–40:45 min.	14 (4 fish)

Four mice were used in testing each extract. The average death times were as follows (min : sec) :

muscle—26 :21 (range : 17 :15-30 :00)
liver—14 :31 (range : 8 :54-17 :30)
intestines—negative, mice remained asymptomatic.

It will be noted that in the case of the Guaymas specimens, the musculature was found to be nontoxic, while that of the San Felipe specimen gave a strongly positive reaction. Thus, it can be seen that the toxicity of the same organs of the puffer are subject to considerable variation. Whether this fluctuation is on a seasonal, regional, or merely anatomical basis has not been determined thus far. The problem of toxicity fluctuation in puffers has been discussed in detail elsewhere (Halstead and Bunker 1953). Studies are now in progress which should shed additional light on the matter.

SUMMARY

The toxicity of extracts obtained from the muscle, liver, and gonads of 12 specimens of the gulf puffer *Sphoeroides annulatus* (Jenyns) collected near Guaymas, Sonora, Mexico, is reported. Also included are data from one specimen of this species collected from San Felipe, Baja California. Of the 12 fish from Guaymas, 11 had strongly toxic livers and four specimens had strongly toxic gonads. None of the muscle extracts from the Guaymas specimens proved to be toxic. However, the muscle extract as well as that of the liver from the San Felipe specimen was strongly toxic. The extract from the intestine of the San Felipe fish was negative. Apparently the toxicity level of the gulf puffer *S. annulatus* is subject to considerable fluctuation.

Exactly what the factors are which control toxin production is not known at this time. The high incidence of toxicity in the livers over that of the other organs may have some significance since the liver is generally considered to be the principal organ for detoxification in the body. This present study was conducted preliminary to a more extensive investigation concerning the origin and physiological actions of the toxin from *S. annulatus*.

The results of this study reveal that the musculature and viscera of the gulf puffer, *S. annulatus* (Jenyns), are frequently toxic, hence should not be considered for human consumption.

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OBSERVATIONS ON THE EFFECT OF BLACK POWDER EXPLOSIONS ON FISH LIFE[1]

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This article describes a field test used to verify the recommendations of Hubbs and Rechnitzer in their paper "Report on Observations Designed to Determine Effect of Underwater Explosions on Fish Life."

The effect of explosions on fish was made very prominent off the California coast by the desire of various oil companies to make geophysical explorations of the formations beneath the waters adjacent to the California coast. The method first used involved the use of submarine explosions of dynamite to produce a shock wave which would travel downward through the earth and be reflected from various underlying rock strata. By plotting the depth of these strata at many different points, it was possible to map the subsurface geology and pick out the spots at which oil was most likely to be discovered.

California law made it necessary for the oil companies to obtain permits from the Fish and Game Commission before firing explosives underwater. To summarize a long, complex and acrimonious story, the dynamite explosions killed large numbers of fish in spite of many careful precautions which were taken, and the Fish and Game Commission refused to issue any further permits for this type of survey work until such time as it could be demonstrated that markedly less harmful methods had been evolved. The Union Oil Company was, however, granted a joint permit with the Scripps Institute of Oceanography to conduct experiments intended to work out such a method. It is the result of these experiments which are reported by Hubbs and Rechnitzer.

The experimental work indicated that black powder (Hercules FFG and FFFG black powder) produced the survey results desired, without appreciable fish kill. Permits were then granted to continue the submarine geophysical exploration. The work is so expensive that several oil companies banded together in a joint operation. Many precautions were taken, and careful application was made of the findings of a first-class piece of research. The net result was so good that one Fish and Game observer permanently attached to the project reported that the fish killed were so few that "one good fisherman with a rod and reel could catch more in a day than the geophysical operations killed in three months." The powder now used is referred to as Hercules E.P. 138 Seismograph Black Powder or as FFFFG sporting grade black powder.

Every observer who was on the spot found the survey operations essentially harmless, but some "observers" who never got within a mile or two of the operations and some rumor listeners complained to the Fish

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and Game Commission that the explosions must be killing fish in large numbers.

These complaints seem to have been based on the fact that the earlier dynamite explosions had killed fish and that the black powder explosions threw water about as high and from a distance looked as though they must be just as deadly. At one commission meeting, the point was brought up (not for the first time) that many dead fish sink. A commercial abalone diver (Antone Sylvester of Avila) reported that he had seen tremendous numbers of dead fish on the bottom where there were few, if any, showing on the surface. Mr. Sylvester stated frankly that this was during the period when dynamite was being used and that he had no first-hand knowledge of the effects of black powder.

As a result of these complaints, it was decided to send divers to the bottom immediately after each of several explosions and determine whether or not any damage had been done. Accordingly, on June 16 and 17, 1952, the Department of Fish and Game's biological research diving crew joined the seismic operations in the vicinity of Port San Luis. The junior author did the diving. The oil companies had also invited newspaper representatives, sportsmen, county officials, commercial fishermen and others. They provided a large observation boat and a diver of their own who worked from this boat. Also chartered by the companies was an abalone diving boat which was used by the Fish and Game diving crew. On the sixteenth, Mr. Sylvester was on deck as an observer representing the commercial fishing industry. He was so interested that on the following day, he appeared with his diving boat, gear, and crew and joined the other two divers.

The normal method of operation is about as follows: a string of 12 hydrophones floated on a 1,000-foot cable by means of numerous inflated buoys is strung out behind the ship carrying all the sound recording instruments. One end of this cable remains on the ship; the other end is held by a water taxi. A second water taxi holds a second string of hydrophones at an angle to the first, with the instrument ship at the apex of the "v." A third water taxi then drops a charge of 45 or 90 pounds of black powder in one or two five-gallon cans. One 45-pound can is used within a mile of shore, two cans are used farther out. No shots are fired within a half mile of shore. The powder is prevented from sinking more than six feet below the surface by a pair of inflated balloons. This depth gives the best results for geophysical purposes. The charge is fired electrically. The Fish and Game observer then immediately goes through the area (in still another water taxi) to observe whether or not any fish have been injured. The three boats carrying the cables then move a short distance and the process is repeated. Forty or 50 shots are a normal day's work, though as many as 170 have been fired. The explosions throw a tremendous column of spray about 200 feet into the air and look very impressive, but they make surprisingly little noise (a "poof" rather than a "bang") and give a jar that is barely noticeable to passengers on a boat 30 to 50 yards away.

On the trip involving the Fish and Game diving crew, the procedure outlined above was followed on June 16th except that immediately after the explosion, the Fish and Game and oil company divers went down in the area affected by the explosion. The presence of the diving crews

slowed operations down markedly and on this day only three blast areas were searched by the divers before the afternoon wind made it necessary to suspend diving operations. In each instance the divers stayed down for about 20 minutes and searched the bottom under the point of detonation and within a radius of about 100 feet. A few small flatfish were found, all alive and apparently uninjured. No dead or injured fish were found. Clams and tube worms were found, none of which had suffered ill effects from the blast. These animals all responded in the normal manner by quickly withdrawing siphons and tentacles when touched by the diver.

On June 17th it was decided to give the black powder method a more severe test. After some searching, a school of rockfish, *Sebastodes*, was discovered in approximately 55 feet of water. All the divers descended and all found fish and returned to their boats. A standard 45-pound charge was then fired six feet under the surface. The three divers again descended and all found live fish in quantity, none of which appeared to be harmed in any way.

The junior author's findings in more detail were as follows: Before the blast he found isolated rock ridges projecting about 10 feet above a coarse sandy bottom. Growing on these rocks were many white sea anemones, ranging from one to six inches in diameter and two inches to two feet high. Many tube worms were attached and growing at the base of the rocks and in the crevices. Sea urchins, various corals, and sea cucumbers were also in abundance on the rocks. Rockfish were observed swimming about. After the blast the rockfish, all apparently uninjured by the blast, were swimming as usual about the rocks. The bottom sand and silt was undisturbed. Visibility was the same as before the blast. Objects could be discerned about six feet away. None of the invertebrates seemed to be affected; the sea anemones were extended, as were the tube worms; none of the corals had been broken; the sea urchins were still on the rocks and the sea cucumbers had not contracted. While ascending, he came through a school of blue rockfish (*Sebastodes mystinus*) which were congregated 20 to 30 feet below the surface. None of these fish seemed to have been affected and several exhibited a lively curiosity toward the diver, following him up as he was being pulled to the surface. No vertebrate or invertebrate appeared to have been affected in any way by the explosion.

Even before the divers were on the bottom, the senior author started fishing under the point of detonation with a rod, reel, and a chrome-plated jig. Angling was quite good. Seven rockfish of three species were taken in a very few moments.

No tests were made of 90-pound charges of black powder. This was because the test shots were fired less than one mile off shore and a State Lands Commission ruling prohibits firing of more than 45 pounds this close to land. Probably it would have been easy to have obtained special permission to fire a larger charge on this occasion, but it had been decided to fire exactly the charges which would normally be used. Further experimenting would have been interesting, but the seismic operations cost approximately $5,000 per day, and there would seem to be little chance there would be any unseen damage done by larger charges fired farther off shore (and usually in deeper water). Observations by the fish and game observer attached to the seismic operations indicate that almost no damage is done by large or small charges.

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THE 1952 SHARK DERBIES AT ELKHORN SLOUGH, MONTEREY BAY, AND AT COYOTE POINT, SAN FRANCISCO BAY[1]

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THE ELKHORN SLOUGH DERBIES

Two shark derbies were held recently at Elkhorn Slough at Monterey Bay, California. The first, on June 8, 1952, was marked by a registration of 308 fishermen and a total catch of 108 sharks and rays (1,800 pounds). The second, held eight weeks later on July 27, resulted in a registration of 322 fishermen and a total catch of 106 sharks and rays (1,111 pounds). Sponsorship of the June 8 derby was by the Pajaro Valley Rod and Gun Club of Watsonville, California, and on July 27 by the Castroville Rod and Gun Club. At both derbies fishing was limited to the five hours between 7 a.m. and 1 p.m. with all specimens being returned to the Moss Landing Committee stand for judging. Table 1 presents the details of the catch results and a comparison with the 1951 derby.

Several rarities were among the catches. The first was a 750 mm., $5\frac{3}{4}$-pound, female thornback (*Platyrhinoidis triseriata*); this is now cataloged as No. 20586 in the collections of the Department of Ichthyology of the California Academy of Sciences. Mr. W. I. Follett, who is making a detailed study of the synonomy of California fishes, advises me that this specimen of thornback is the first recorded corroboration of the original tabulation of Jordan and Gilbert (1881, p. 458). Their use of an "X" in the San Francisco column of their table indicated that they must have had a specimen from that locality, although their next specimen was from Santa Barbara, and there was none from the area between the two localities. Otherwise the northernmost recorded specimen was found on the beach immediately north of Pt. Conception by Dr. Carl L. Hubbs (1916).

Other rarities included two male specimens of the round stingray (*Urobatis halleri*). The first, 372 mm. and $1\frac{5}{16}$ pounds, was taken June 8 (CAS 20587), and the second, 405 mm., $1\frac{6}{16}$ pounds, was taken July 27 (CAS 20620). From Mr. Follett's studies, the northernmost record for this species is again credited to Dr. Hubbs (1920). He observed a specimen on the sandspit at the mouth of the estero at Goleta just north of Santa Barbara. The latter site is the type locality for the species. Thus the range of the round stingray is extended an approximate 170 air-line miles, or about 200 coastline miles northward from Goleta to Elkhorn Slough, Monterey Bay.

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One of the smallest sharks taken at the July derby (280 mm. male) was found after laboratory examination to be a gray smoothhound (*Mustelus californicus*). This is the first known specimen of this species taken in the slough. Despite the fact that the type locality for the gray smoothhound is San Francisco, where it is not now known to occur, its northernmost range for the present will have to rest on this immature specimen (CAS 20619).

The largest fish of the June derby was a female bat ray of approximately 100 pounds; this is a slight increase in size over the 85-pound prize-winning specimen of the previous year. For the July derby the largest fish was again a female bat ray but this time the weight was much less, i.e., 56 pounds. Two tails projecting from the cloaca of this female suggested the possibility of obtaining newborn rays for the aquarium.

TABLE 1

Comparison of Catches Made at the Elkhorn Slough Shark Derbies

	Number caught			Percentage caught		
	May, 1951	June, 1952	July, 1952	May, 1951	June, 1952	July, 1952
Leopard shark						
Triakis semifasciata						
Males	7	15	9			
Females	7	17	7			
Total	14	32	16	23	26.6	15.1
Shovelnose guitarfish						
Rhinobatos productus						
Males	4	3	18			
Females	14	12	31			
Total	18	15	49	29.5	13.9	46.2
Gray smoothhound						
Mustelus californicus						
Males			1			.94
Bat ray						
Holorhinus californicus						
Males	8	27	21			
Females	21	32	18			
Total	29	59	39	47.5	54.5	36.8
Thornback						
Platyrhinoidis triseriata						
Females		1			.925	
Round stingray						
Urobatis halleri						
Males			1			.944
Females		1			.925	
Total catch	61	108	105			
Total weight in lbs.		1,800	1,100			
Number registered fishermen	237	308	322			

Dissection revealed two small females each with pectoral fins neatly folded over the back and lying in the uterus with the posterior part of the bodies directed towards the cloacal opening (Figure 1). Had the Shark Derby not intervened, they would probably have been born within the next few hours but unfortunately they were not alive at the time of removal from the parent.

These unborn rays were 502 and 510 mm. in length (185 mm. from tip of snout to posterior edge of pelvic fins for both) and weighed 401 and 404 grams, respectively (CAS 20621). In both of these specimens the natal scar was still apparent. Most obvious were the extremely long tails. Measurements revealed that the tail length of these, and other very young specimens, was 53 to 63 percent of the total length, whereas older specimens are usually in the 30 to 45 percent range. It is possible that further data will reveal that young bat stingrays lose some of the tip portion of the tail during the first few weeks of life.

These unborn bat rays were apparently fairly good-sized for a small female caught several days later in San Francisco Bay (natal scar not visible) measured only 435 mm. (161 mm. to posterior edge of pelvic fins) and weighed 250.7 grams (CAS 20622). A male bat ray (CAS 20624) caught at the Coyote Point Shark Derby on September 14, measured 400 mm. (151 mm. to posterior edge of pelvic fins) and weighed

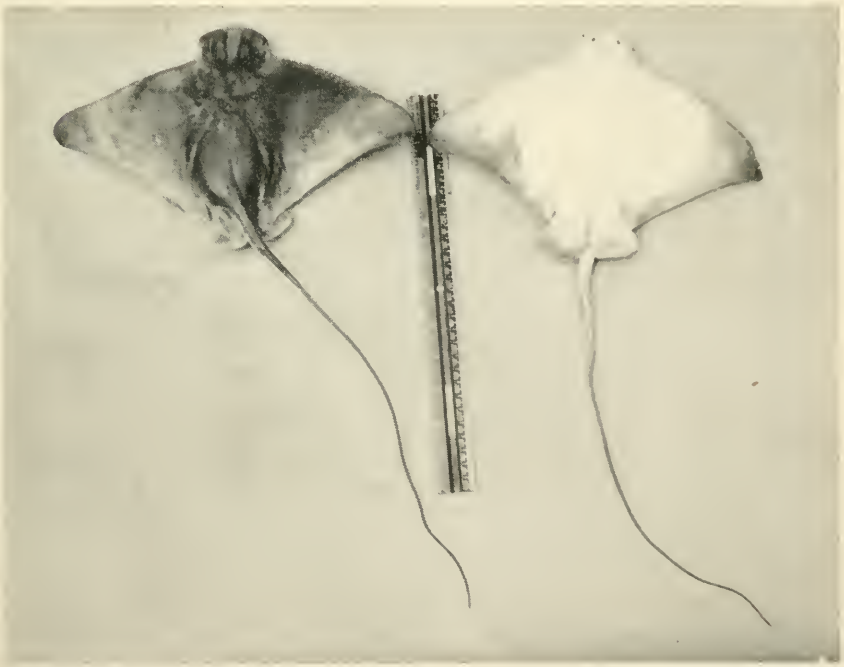

FIGURE 1. Unborn bat stingrays removed from the uterus of the prize-winning 56-pound female at the July, 1952, Elkhorn Slough Shark Derby. See text for discussion of change in the relative lengths of the tails. *Photograph by Kenneth Innes.*

187.3 grams. That this size is approximately that of newborn rays in San Francisco Bay is indicated by four individuals born at about the same time at the diving bell at Fleishacker Beach. These four specimens were transferred to tanks at Steinhart Aquarium where they seemed to do well on a diet of fish pellets. We had them for about a month but unfortunately lost all of them within one week due to an unknown air-bubble disease affecting the internal organs.

Gudger (1951) has recently published a very interesting paper on "How difficult parturition in certain viviparous sharks and rays is overcome." Although he is of the opinion that all rays have tail presentation of young at birth, he was able to find only a few records substantiating this important detail. Suffice to say that California's bat ray agrees with what is known of other rays in having tail presentation at birth.

At the 1951 derby there was an indication of an atypical sex ratio among the bat rays with the catch of 29 specimens being composed of 8 males and 21 females. In the 1952 derbies the ratio was more normal. However, the ratio for shovelnose guitarfish was quite abnormal for both years: for 1951, 4 males and 14 females; and for 1952, 3 males and 12 females; and 18 males and 31 females.

Fluctuation in the guitarfish catch has been marked, although for the first two derbies the numbers caught were about the same, i.e., 18 and 15 specimens, respectively. However, for the third derby the catch of this species was nearly tripled with a total of 49 specimens. Thus, for the three derbies the shovelnose guitarfish were 29, 14 and 46 percent of the total catch. This fluctuation should not be wholly unexpected since guitarfish schools are known to move in and out of shallow bays at irregular intervals. This movement is also true of leopard sharks and such might account for the 16 specimens taken at the July derby as compared with the catch of 32 taken one month earlier at the June derby.

Little is known of the movements of bat rays. The writer suspects that this species has a more static population than does any of the sharks. If such were the case, then the drop in catch from 59 to 39 from the June to the July derby might be partially due to the mortality that occurred at the June derby.

Catch records for the 1951 derby have previously been published by Herald and Dempster (1951).

THE COYOTE POINT DERBY

The Sixth Annual Coyote Point Shark Derby was held on Sunday, September 14, 1952, with the fishing limited to South San Francisco Bay between the hours of 7 a.m. and 3 p.m. Sponsorship was again by the San Mateo Lions Club and the Coyote Point Yacht Club. The total catch of 1871 sharks and bat rays (6,620 lbs.) was the largest recorded for any of the derbies. The 1,484 registered fishermen were 139 fewer than the number that participated in last year's derby. The details of the catch are presented in Table 2, together with a comparison with previous years. The data for the 1951 derby has not been reported although the earlier data appears in Herald and Ripley (1951).

TABLE 2

Comparison of Catches Made at the Coyote Point Shark Derbies

	Number caught				Percentage caught			
	June, 1948	Sept., 1950	Sept., 1951	Sept., 1952	June, 1948	Sept., 1950	Sept., 1951	Sept., 1952
Brown smoothhound *Rhinotriacis henlei*	51	539	712	798	11.8	53	51.7	42.6
Leopard shark *Triakis semifasciata*	57	261	312	490	44.2	25.7	22.6	26.2
Dogfish *Squalus acanthias*	0	5	99	23	0	.5	7.2	1.2
Soupfin *Galeorhinus zyopterus*	0	60	26	200	0	5.9	1.9	10.7
Sevengill cowshark *Notorynchus maculatum*	12	59	168	301	9.3	5.8	12.2	16.1
Sixgill cowshark *Hexanchus griseus*	0	1	0	0	0	.01	0	0
Thresher *Alopias vulpinus*	0	1	0	0	0	.01	0	0
Bat ray *Holorhinus californicus*	6	89	61	59	4.7	8.8	4.4	3.2
Total catch	129	1,015	1,378	1,871				
Total weight in lbs.		4,216	6,550	6,620				
Number registered fishermen	*982	*1,406	*1,623	*1,484				

* The number of registered fishermen may not be too significant since many persons buy tickets in order to help the derby's objectives (child aid and child care) or to be eligible for the drawing for the prizes.

The largest shark captured at the 1952 derby was again a sevengill —an 84-pound female which upon dissection was found to be sexually immature. The stomach contained the large head of what had apparently been a striped bass of some 20 pounds. This was the third largest sevengill known from the bay. The largest, a 177-pound specimen, was caught by Don Hunter off Brisbane during 1941. The second largest weighed 106½ pounds and was taken during the Fish and Game San Francisco shark survey of 1943. At the other shark derbies the largest sharks (sevengills) weighed 34, 20, 27½ and 64 pounds respectively. The increase in number of sevengills has been pronounced (168 specimens of the 1950 derby representing 5.8 percent of the total catch, as compared with the 301 specimens of the 1952 derby representing 16 percent of the total catch).

One of the strangest specimens of the 1952 derby was what was apparently an albino sevengill (Figure 2). This specimen, now cataloged as CAS 20623, did not have the pink eyes usually considered the mark of the true albino. The iris was unpigmented and the pupil dark blue, whereas the reverse was the case in other preserved sevengills, i.e., the

FIGURE 2. An albino sevengill shark (870 mm.) caught at the 1952 Coyote Point Shark Derby —photographed alongside another specimen with normal pigmentation. Both were preserved at the time the photograph was taken. *Photograph by Kenneth Innes.*

iris dark-colored and the pupil white. Whether this is a case of pseudo-albinism due to a glandular deficiency, or true albinism due to heredity, remains to be determined.

The second surprise of the derby was the tremendous increase in the number of soupfin. Although these sharks were not eligible for prize awards since it is illegal to catch them in the bay, nevertheless there were 200 of them (10.7 percent of total catch) brought to the judge's stand. The writer was able to find only one fisherman who had recognized the soupfin while fishing and he had thrown back about 18 individuals (not recorded in Table 2). Thus the lack of a commercial soupfin fishery seems to be having a beneficial effect on the species—provided that the Coyote Point Shark Derby catches are any true indication.

Another strange specimen should be mentioned. One of the 490 leopard sharks had a heavy rubber band around its gill area (Figure 3). Sharks and other fishes with bands around parts of their bodies have not been unknown in the past but this is apparently the first in California. The shark probably picked up the band while nosing over the bottom in search of food, and this undoubtedly occurred when the shark was much smaller. However, the possibility is not to be ruled out that the band was placed on the shark by some pseudo humorist when it was caught—and then subsequently released. Dr. Gudger has reported several cases—a mackerel with a rubber band through the center of its body (1928); a 15-foot mackerel shark with an automobile tire around its midriff (1931); haddock, dogfish, halfbeaks and mackerel with rubber bands (1937); and fishes with iron rings about the body (1938).

Data on these derbies were taken by Kenneth Innes, Walter Schneebeli, Norval Green, Robert Dempster, Leonard Goodman, Robert Van Bozarth and the writer.

FIGURE 3. From the Coyote Point Shark Derby, a 30-inch leopard shark with a heavy rubber band around the gill region. There was no indication of wearing on the undersurface of the body, although there was considerable erosion on dorsal surface. *Photograph by Kenneth Innes.*

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NEW FISHWAYS ON THE YUBA AND FEATHER RIVERS[1]

By J. A. APLIN
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As part of a long term program for the betterment of fishing in California, the Department of Fish and Game has been investing in basic stream improvement. Money for this work has been made available by the allocation of funds from the tax on pari-mutuel horse race betting. The program of wildlife restoration is supervised by the Wildlife Conservation Board. Three large fish ladders have been completed as part of this work.

Two of the new fishways are at Daguerre Point dam on the Yuba River about 10 miles up the river from Marysville. Above the dam there are 15 miles of gravel beds suitable for salmon spawning. Since the dam was built, there have been very few salmon nests found in this upstream area in marked contrast to the stream bed below the dam where many salmon nests are found each year. This is in spite of the fact that the upstream channel is more desirable as a breeding area because it contains water throughout the year. There was an old ladder at the south end of the dam (Figure 1) made by building concrete walls across a narrow channel in the rock with the upper portion built of planking. This wooden portion was destroyed by high water several years ago.

The 700-foot length of this dam made a ladder at each end necessary if the fish were to get over before becoming exhausted. Also an island near the middle of the dam separates the downstream channel for 150 yards. It is quite unlikely that a fish reaching the dam on one side of this island would ever get to a ladder on the other side.

Making any structure stand that is exposed to the river at this location is difficult because of the small rocks and sand which are carried by the water at high flows. The abrading action of this gravel makes heavy construction imperative. The new ladder at the south end of the dam was started in September, 1950. To reach the site, construction equipment had to be brought across the top of the dam and unusually high water early in the fall slowed completion of the job. However, the project was finished early enough in 1951 to be used by the runs of anadromous fish arriving later in the spring. At one time five kinds of migrating fish were seen in this ladder. As well as the expected king salmon and steelhead, there were shad, striped bass and squawfish.

[1] Submitted for publication September, 1952.

FIGURE 1. Remains of the old ladder at the south end of the Daguerre Point dam, Yuba River. *Photograph by D. H. Fry, Jr.*

The fishway on the north end of the dam is shown in Figure 3. Although the high water carried away the concrete forms at the project just as they were ready to have cement poured into them, construction was completed during the summer of 1951 in time for the fall run. Here salmon and steelhead were seen in the ladder at the same time.

FIGURE 2. The new ladder at the south end of the Daguerre Point dam

The combined cost of the two Daguerre Point fishways was $65,000. It is expected that the increased area now made available to spawning will add to the runs of salmon and steelhead ascending the Yuba River in the future.

The largest of the three new fishways is on the Sutter Butte dam in the Feather River. It is located about 10 miles downstream from Oroville and about five miles northeast of Gridley. There has been a fishway on this dam but it has proved definitely unsatisfactory. Several reasons contribute to its lack of effectiveness. As this old fish ladder is not accessible from either bank of the river except at very low water, no adjustment of the flow through it can be made. Also, the dam is several hundred feet long which makes it difficult for fish to find the entrance. This factor is aggravated by the position of the entrance about 20 feet downstream from the face of the dam.

During some years when a heavy flow in the river occurs, at the time of the upstream migration of salmon, the fish pass over the dam without much trouble. However, this is the exception and cannot be depended upon.

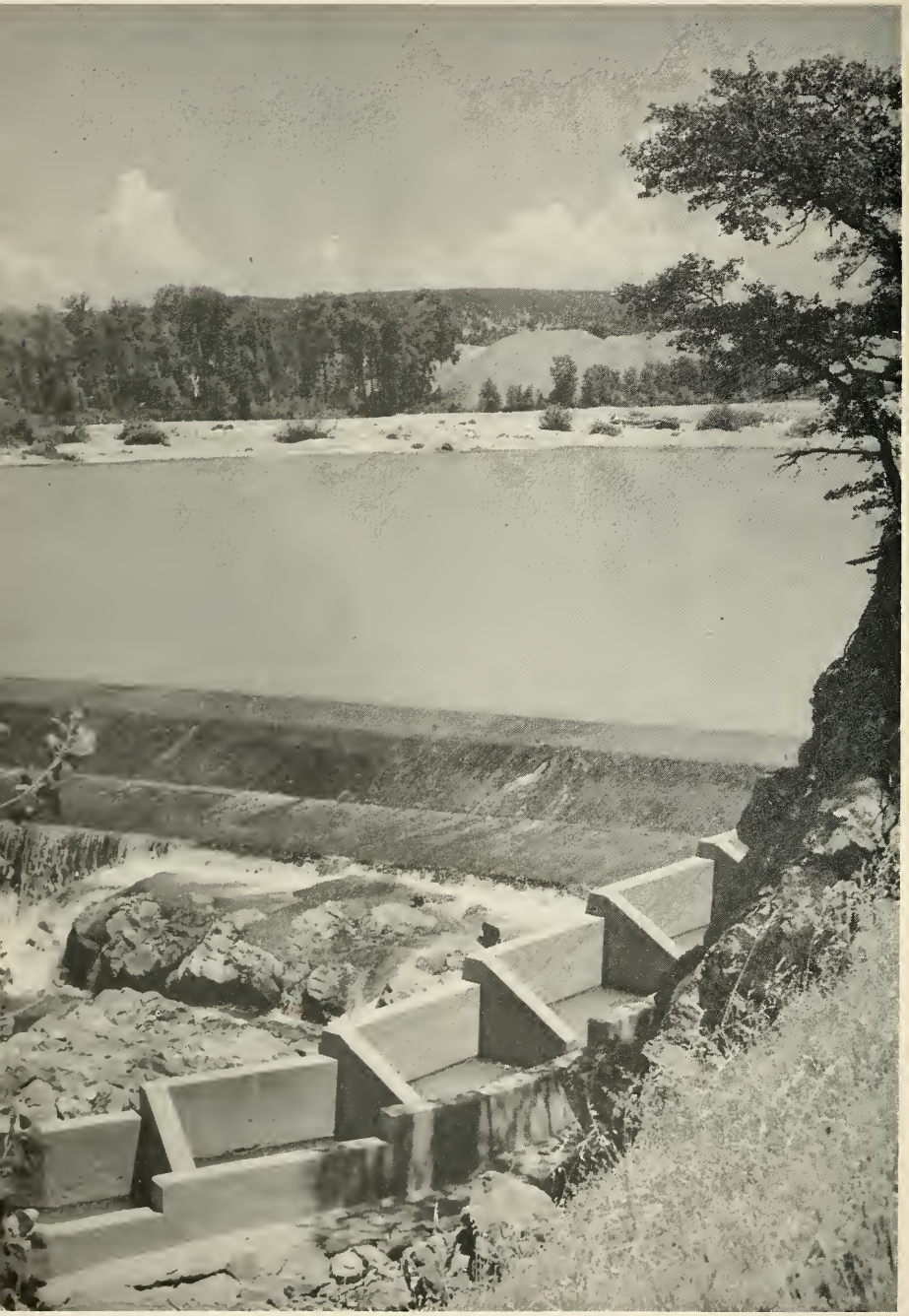

FIGURE 3. Fishway at the north end of the Daguerre Point dam.
Photograph by J. A. Aplin, July, 1952.

FIGURE 4. The new fishway at Sutter Butte dam on the Feather River.
Photograph by J. A. Aplin, July, 1952.

Work on the new fishway was begun in October of 1950. Construction was difficult, as the river bed at this location is composed of large cobbles to a considerable depth. These shifting rocks made the building of a cofferdam around the foundation area slow and the upwelling of water from below hard to stop. Exceptionally high water within a month after work was started destroyed the cofferdam and washed away a number of the concrete forms. Work had to be abandoned until the lowering of the water in the summer of 1951. On October 24, 1951, a flow of water was started through the fishway, although work was still going on, and within a few minutes upstream migrating salmon were seen entering it. Within an hour several dozen fish had passed through the ladder and others were coming in an almost continuous procession. This was particularly encouraging as the fish had to jump over a temporary wall which had only six inches of water flowing over it. This wall was removed a few days later and access into the fishway was much easier. The project was officially completed on November 8, 1951, at a cost of $45,000.

OFFICIAL COMMON NAMES OF CERTAIN MARINE FISHES OF CALIFORNIA[1]

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PURPOSE OF OFFICIAL NAMES

The fundamental reason for the State's assigning official names to its marine fishes is to assist in the collection of accurate catch statistics. For the Department of Fish and Game to understand the State's many fisheries it is essential that the catch, both sport and commercial, of each species be known. A consistent terminology on the part of both the industry and sportsmen is of vital importance in the collection of accurate records, for confusion and inaccuracy will result if a given species is listed by different names in different parts of the State and if a certain name can mean any of several species.

LEGISLATION

The importance of uniform terminology was recognized years ago by the State Legislature. According to Walford (1931, p. 5) a law enacted in 1919 provided that "The Fish and Game Commission shall have the power to decide what is the common usage name of any variety." In 1933, the law was changed to its present form. Article 5 (Commercial Fishing Reports), Section 1093, of the Fish and Game Code provides that:

> "The names used in the receipt for designating the species of fish dealt with must be those in common usage, and may be designated by the commission."

While this law applies specifically only to commercial landings, and consequently, to species entering the commercial catch, it has been the policy of the department to assign common names to other than commercial varieties, both fresh water and salt, to insure uniformity in State publications and records and to attempt to attain uniformity in common usage on the part of all fishermen.

PRIOR LISTS

The first comprehensive list of official names appeared in Fish Bulletin No. 28 (Walford, 1931). This list covered the more important fresh-water fishes as well as the leading marine bony fishes, sharks and rays. A few years later sharks and rays were treated more fully in Fish Bulletin No. 45 (Walford, 1935). By the late 1940's, stocks of both of these bulletins were exhausted and in new publications it seemed wise to change several

[1] Submitted for publication December, 1952.

of the authorized names—some because they were coined and were not accepted by the public, others because they proved a detriment in marketing. The revised official list of marine bony fishes appeared in Fish Bulletin No. 68 (Roedel, 1948) and the reasons for the changes made were set forth by Roedel (1949). Fish Bulletin No. 75 (Roedel and Ripley, 1950) contained accounts of all species of sharks and rays known from the State and to each an official name was assigned. All fresh-water species of the State were assigned names by Shapovalov and Dill (1950).

PRINCIPLES GOVERNING OFFICIAL LISTS

Stability is of prime importance if a list of official names is to serve its purpose. Once established, a name should never be changed unless there are substantial reasons for it. While changing the name of an unimportant variety not segregated as a species by the fisherman would have little or no effect on the record system, any change affecting a major variety could have a serious effect. However, "official" names are patently worthless if they are not used. Errors will occur in the selection of names and common usage will change. Particularly, attempts to apply "logical" vernaculars in the face of established "inappropriate" names are usually doomed to failure. Further, it has happened that common usage names lacking in "sales appeal" have been assigned to species then of no significance only to have them emerge as commercial varieties but handicapped on the market by unappetizing vernaculars. A certain latitude must be allowed to care for these situations.

Several rules have governed the selection of official names, all subject to the guiding principle that the purpose of the names is to assist in the compilation of accurate records.

Ideally, a name should be in sole use throughout a species' range and would not be applied to any other North American species. Unfortunately, relatively few names have such universal and sole application. It then becomes necessary to evaluate such names as are applied to a species with regard for the points which follow:

1. Usage in California by both commercial and sport fishermen and the fishing industry.
2. Usage in other areas, particularly adjacent states.
3. Usage on other official lists.
4. The name should not have undesirable connotations which might impair marketability.
5. The name should be brief and descriptive.
6. The name should indicate rather than confuse relationships.

In practice in recent years, points one and four have carried the most weight. Other lists, particularly that of the American Fisheries Society (1948), have been given full consideration. However, usage on the Pacific Coast, particularly in California, prevents our adopting all accepted names on these lists. The departures express the consensus of California workers and it is hoped that future committees on common names will give due consideration to Pacific Coast terminology. Point six has been given the least consideration. This is an unfortunate circumstance, but it is nonetheless true that some of our most firmly established vernaculars

are completely misleading. However, it would be futile to attempt their overthrow.

In those cases where a species is not recognized as such by fishermen but is simply included in a broad category, such as "smelt," it is possible to make a more "logical" selection. However, since the species is not segregated by fishermen, giving it a name is largely an academic matter. The name will probably never get beyond the bounds of the literature unless (as has happened) the species suddenly becomes of economic importance for itself and not as part of a general category. Because of this chance, point four should never be overlooked in selecting names for obscure forms.

Changes seem inevitable no matter how carefully initial selections may have been made. In general they have been made for one or more of the following reasons:

1. To adopt established vernacular names or, lacking them, more appropriate names in those cases where the original official names met with no popular favor or proved inappropriate or misleading; e.g., "lingcod" for "Pacific cultus."

2. To adopt names desired by the industry for marketing purposes; e.g., "jack mackerel" for "horse mackerel."

3. To make the names for species seldom caught by or not separated in the catch by California fishermen conform with names used by other agencies and/or in other areas; e.g., "C-O turbot" for "mottled turbot."

THE PRESENT LIST

This list includes some species not included in previous lists. None are of major significance in the State's fisheries but all appear sufficiently often to make official appellations seem wise. A few Mexican species not recorded from California waters are included as well because they are taken by California vessels or are of importance in California markets. These are marked with a dagger (†).

In general, names have been given only to species likely to be caught by sport and commercial fishermen either by design or by accident. However, all sharks and rays known from the State are included because names had been given them by Roedel and Ripley (1950).

All changes, other than minor emendations in orthography and additions of optional attributives, are discussed at the appropriate place in the list. (Reasons for changes made from the lists of Walford, 1931 and 1935, and discussed by Roedel, 1949, are not restated.)

A feature new to the official list is the sanctioning of a few alternative names, where two vernaculars are applied to the same fish in California and either name will lead to ready identification of the species in question. The preferred name is given primary listing.

Another departure from previous lists lies in the use of optional attributives. These will be found enclosed in parenthesis which indicate that another species with the same vernacular is found outside of the State's boundaries. Such attributives need not be used unless their omission might, in any given report or record, result in confusion with a species found elsewhere.

An asterisk denotes a name not previously listed.

The names represent the consensus of departmental staff members. While it cannot be expected, in view of past experience, that this list will be immutable, we do hope that it more nearly approaches general acceptance.

Our thanks, for their cooperation, go to Dr. C. L. Hubbs, Scripps Institution of Oceanography, La Jolla, Mr. W. I. Follett, California Academy of Sciences, San Francisco, and Mr. Raymond Cannon, Hollywood, all of whom have given much thought to the vexing problems of vernaculars in connection with their own projected publications and with whom we have reached substantial agreement.

COLLECTIVE TRADE NAMES

In compiling catch records, a number of species are often grouped under one name, even though each species may have its own official name. This may be because the species are so alike in general appearance that little or no effort is made to separate them in the markets, because little reliance can be placed on the market identification or because only part of the total catch can be assigned accurately to the several species.

The species composition is, in most cases, evident; for example, "sanddab" might include any of the three species known from the State. However, some trade names are deceptive and may include members of two or more families. These names include:

1. **Eel.** Includes moray (*Gymnothorox mordax*), monkeyface-eel (*Cebidichthys violaceus*) and rock-eel (*Xiphister mucosus*).
2. **Hardhead.** Includes two fresh-water species, greaser blackfish (*Orthodon microlepidotus*) and hardhead (*Mylopharodon conocephalus*).
3. **Kingfish.** Includes queenfish (*Seriphus politus*) and white croaker (*Genyonemus lineatus*).
4. **Perch.** Includes all surfperches (family Embiotocidae), blacksmith (*Chromis punctipinnis*), halfmoon (*Medialuna californiensis*), opaleye (*Girella nigricans*) and sargo (*Anisotremus davidsoni*).
5. **Rock bass.** Includes the three members of genus *Paralabrax* (kelp, sand and spotted basses).
6. **Smelt.** Includes various silversides (family Atherinidae) and various smelts (family Osmeridae).
7. **Whitebait.** Includes smelts (family Osmeridae) and may include the young of other fishes.

COMMON AND SCIENTIFIC NAMES

FAMILY HETERODONTIDAE—Horn Sharks

(California) horn shark ..... *Heterodontus francisci* (Girard)

FAMILY CHLAMYDOSELACHIDAE—Frill Sharks

Frill shark ..... *Chlamydoselachus anguineum* Garman

FAMILY HEXANCHIDAE—Cowsharks

Sixgill cowshark ..... *Hexanchus griseum* (Bonnaterre)

Sevengill cowshark ..... *Notorynchus maculatum* Ayres

"Cowshark" adopted in place of "shark" as an aid in defining relationship.

FAMILY ALOPIIDAE—Threshers

(Common) thresher — *Alopias vulpinus* (Bonnaterre)

FAMILY LAMNIDAE—Mackerel Sharks

Salmon shark — *Lamna ditropis* Hubbs & Follett

Formerly "mackerel shark." Salmon shark is the true vernacular in the Pacific Northwest. The species is relatively uncommon in California and does not have a local name. Further, "mackerel shark" is applied by the American Fisheries Society to an Atlantic species.

Bonito shark — *Isurus glaucus* (Müller & Henle)

Man-eater — *Carcharodon carcharias* (Linnaeus)

Formerly "great white shark." "Man-eater" is a widespread name and certainly has the advantage of brevity and force. Rare in California.

FAMILY CETORHINIDAE—Basking Sharks

Basking shark — *Cetorhinus maximus* (Gunner)

FAMILY SCYLIORHINIDAE—Catsharks

Filetail catshark — *Parmaturus xaniurus* (Gilbert)

Brown catshark — *Apristurus brunneus* (Gilbert)

"Catshark" adopted in place of "shark" as an aid in defining relationship.

(California) swell shark — *Cephaloscyllium ventriosum* (Jordan & Gilbert)

FAMILY TRIAKIDAE—Smoothhounds

Leopard shark — *Triakis semifasciata* Girard

Brown smoothhound — *Rhinotriacis henlei* Gill

Gray smoothhound — *Mustelus californicus* Gill

Sicklefin smoothhound — *Mustelus lunulatus* Jordan & Gilbert

FAMILY CARCHARHINIDAE—Requiem Sharks

Tiger shark — *Galeocerdo cuvieri* (Peron & LeSueur)

Soupfin — *Galeorhinus zyopterus* Jordan & Gilbert

Blue shark — *Prionace glauca* (Linnaeus)

Formerly "great blue shark." The initial adjective was misleading.

Bay shark — *Carcharhinus lamiella* (Jordan & Gilbert)

Roundnose shark — *Carcharhinus azureus* (Gilbert & Starks)

Listed by Roedel and Ripley (1950) as "gambuso" utilizing a Mexican vernacular. The new name is deemed more appropriate for use in the United States. This species is very rare in California.

(Pacific) sharpnose shark — *Scoliodon longurio* (Jordan & Gilbert)

FAMILY SPHYRNIDAE—Hammerheads

Common hammerhead * — *Sphyrna zygaena* (Linnaeus)

Scalloped hammerhead * — *Sphyrna lewini* (Griffith)

Bonnethead — *Sphyrna tiburo* (Linnaeus)

FAMILY SQUALIDAE—Dogfishes

Dogfish — *Squalus acanthias* Linnaeus

Bramble shark — *Echinorhinus brucus* (Bonnaterre)

(Pacific) sleeper shark — *Somniosus pacificus* Bigelow & Schroeder

FAMILY SQUATINIDAE—Angel Sharks

(California) angel shark — *Squatina californica* Ayres

FAMILY RHINOBATIDAE—Guitarfishes

Shovelnose guitarfish — *Rhinobatos productus* (Ayres)

Mottled guitarfish — *Zapteryx exasperata* (Jordan & Gilbert)

FAMILY PLATYRHINIDAE—Thornbacks

(California) thornback — *Platyrhinoidis triseriata* (Jordan & Gilbert)

* Species previously not listed.

FAMILY RAJIDAE—Skates

California skate ——— *Raja inornata* Jordan & Gilbert
Big skate ——— *Raja binoculata* Girard
Longnose skate ——— *Raja rhina* Jordan & Gilbert
Starry skate ——— *Raja stellulata* Jordan & Gilbert
Roughtail skate ——— *Raja trachura* Gilbert
Sandpaper skate ——— *Raja kincaidi* Garman

Formerly "black skate," inappropriate in that the color is not at all black. The skin is actually the color and texture of sandpaper.

FAMILY DASYATIDAE—Stingrays

Round stingray ——— *Urobatis halleri* (Cooper)
Diamond stingray ——— *Dasyatis dipterurus* (Jordan & Gilbert)
(California) butterfly ray ——— *Gymnura marmorata* (Cooper)

Formerly "butterfly stingray." The sting is either small or absent and hence "stingray" was considered misleading.

FAMILY MYLIOBATIDAE—Eagle Rays

Bat ray ——— *Holorhinus californicus* (Gill)

Formerly "bat stingray." This name does not have particular usage while "bat ray" is heard rather frequently.

FAMILY MOBULIDAE—Mantas

(Pacific) mobula ——— *Mobula lucasana* Beebe & Tee-Van
(Pacific) manta ——— *Manta hamiltoni* (Newman)

FAMILY TORPEDINIDAE—Electric Rays

(California) electric ray ——— *Torpedo californica* Ayres

FAMILY CHIMAERIDAE—Chimaeras

Ratfish ——— *Hydrolagus colliei* (Lay & Bennett)

FAMILY ACIPENSERIDAE—Sturgeons

White sturgeon ——— *Acipenser transmontanus* Richardson
Green sturgeon ——— *Acipenser medirostris* Ayres

FAMILY ELOPIDAE—Tenpounders

(Pacific) tenpounder ‡ ——— *Elops affinis* Regan

FAMILY ALBULIDAE—Bonefishes

Bonefish ——— *Albula vulpes* (Linnaeus)

FAMILY DUSSUMIERIIDAE—Round Herrings

(Pacific) round herring ——— *Etrumeus acuminatus* Gilbert

FAMILY CLUPEIDAE—Herrings

Pacific herring ——— *Clupea pallasi* Valenciennes
(Pacific) sardine ——— *Sardinops caerulea* (Girard)
(American) shad ——— *Alosa sapidissima* (Wilson)
(Pacific) thread herring * ——— *Opisthonema libertate* (Günther)

FAMILY ENGRAULIDAE—Anchovies

Northern anchovy ——— *Engraulis mordax* Girard
Ocean northern anchovy ——— *E. m. mordax* Girard
Bay northern anchovy ——— *E. m. nanus* Girard
Deepbody anchovy ——— *Anchoa compressa* (Girard)
Slough anchovy ——— *Anchoa delicatissima* (Girard)
Anchoveta * ——— *Cetengraulis mysticetus* (Günther)

* Species previously not listed.
‡ Gulf of California species known in California only from the Salton Sea.

FAMILY OSMERIDAE—Smelts

Whitebait smelt * *Allosmerus elongatus* (Ayres)
Eulachon *Thaleichthys pacificus* (Richardson)
The name "candlefish" has considerable general usage and is heard almost exclusively along that portion of the California coast where the species occurs. It is sanctioned as an alternative name.
Night smelt * *Spirinchus starksi* (Fisk)
Sacramento smelt *Spirinchus thaleichthys* (Ayres)
Surf smelt *Hypomesus pretiosus* (Girard)
Freshwater smelt *Hypomesus olidus* (Pallas)

FAMILY SALMONIDAE—Trouts

Pink salmon *Oncorhynchus gorbuscha* (Walbaum)
Chum salmon *Oncorhynchus keta* (Walbaum)
King salmon *Oncorhynchus tshawytscha* (Walbaum)
"Chinook salmon" is sanctioned as an alternative name. Though "king" has heretofore been the only name accepted by California, "chinook" is widely used in the State and dominates in Oregon and Washington. In Alaska, to the contrary, "king" is used virtually exclusively.
Silver salmon *Oncorhynchus kisutch* (Walbaum)
Sockeye salmon *Oncorhynchus nerka* (Walbaum)
This salmon is of no economic importance in California. We have previously used the name "red salmon," but the consensus in the Pacific Northwest appears to favor "sockeye."
Coast cutthroat trout *Salmo clarki clarki* Richardson
Steelhead rainbow trout *Salmo gairdneri gairdneri* Richardson

FAMILY SCOMBERESOCIDAE—Sauries

(Pacific) saury *Cololabis saira* (Brevoort)

FAMILY BELONIDAE—Needlefishes

(California) needlefish *Strongylura exilis* (Girard)

FAMILY EXOCOETIDAE—Flyingfishes

California flyingfish *Cypselurus californicus* (Cooper)
Mexican flyingfish * *Cypselurus* sp.

FAMILY SYNODIDAE—Lizardfishes

(California) lizardfish * *Synodus lucioceps* (Ayres)

FAMILY ALEPISAURIDAE—Lancetfishes

(Pacific) lancetfish * *Alepisaurus borealis* Gill

FAMILY MURAENIDAE—Morays

(California) moray *Gymnothorax mordax* (Ayres)

FAMILY CYPRINODONTIDAE—Killifishes

(California) killifish *Fundulus parvipinnis* Girard

FAMILY MERLUCCIIDAE—Hakes

(Pacific) hake *Merluccius productus* (Ayres)

FAMILY GADIDAE—Cods

(Pacific) tomcod *Microgadus proximus* (Girard)
(Pacific) cod *Gadus macrocephalus* Tilesius

FAMILY LAMPRIDAE—Opahs

Opah * *Lampris regius* (Bonnaterre)

FAMILY TRACHIPTERIDAE—Ribbonfishes

(California) ribbonfish * *Trachipterus rexsalmonorum* Jordan & Gilbert

* Species previously not listed.

FAMILY BOTHIDAE—Lefteyed Flounders

Bigmouth sole _____ *Hippoglossina stomata* Eigenmann & Eigenmann
California halibut _____ *Paralichthys californicus* (Ayres)
Fantail sole _____ *Xystreurys liolepis* Jordan & Gilbert
Pacific sanddab * _____ *Citharichthys sordidus* (Girard)
Longfin sanddab * _____ *Citharichthys xanthostigma* Gilbert
Speckled sanddab * _____ *Citharichthys stigmaeus* Jordan & Gilbert

The three species of sanddab were formerly listed under the collective term "sanddab."

FAMILY PLEURONECTIDAE—Righteyed Flounders

Arrowtooth halibut _____ *Atheresthes stomias* (Jordan & Gilbert)

Formerly "arrowtooth sole." It is not at present a marketed variety and does not have a vernacular in California save "turbot." The new name agrees with the American Fisheries Society list.

Pacific halibut _____ *Hippoglossus stenolepis* Schmidt
Slender sole _____ *Lyopsetta exilis* (Jordan & Gilbert)
Petrale sole _____ *Eopsetta jordani* (Lockington)
Sand sole _____ *Psettichthys melanostictus* Girard
Diamond turbot _____ *Hypsopsetta guttulata* (Girard)
Curlfin turbot _____ *Pleuronichthys decurrens* Jordan & Gilbert
Hornyhead turbot _____ *Pleuronichthys verticalis* Jordan & Gilbert

Formerly "sharpridge turbot." This fish does not have a vernacular other than "turbot." The new attributive is considered more appropriate and agrees with the American Fisheries Society (which, however, lists it as "hornyhead flounder").

C-O turbot _____ *Pleuronichthys coenosus* Girard
Spotted turbot _____ *Pleuronichthys ritteri* Starks & Morris
Scaly-fin sole _____ *Isopsetta isolepis* (Lockington)
English sole _____ *Parophrys vetulus* Girard
Rock sole _____ *Lepidopsetta bilineata* (Ayres)

Changed from "broadfin sole" to conform more closely with common usage. The new attributive is that used by the American Fisheries Society.

Dover sole _____ *Microstomus pacificus* (Lockington)
Deepsea sole * _____ *Embassichthys bathybius* (Gilbert)
Rex sole _____ *Glyptocephalus zachirus* Lockington
Starry flounder _____ *Platichthys stellatus* (Pallas)

FAMILY CYNOGLOSSIDAE—Tonguefishes

(California) tonguefish _____ *Symphurus atricauda* (Jordan & Gilbert)

FAMILY SERRANIDAE—Basses

Cabrilla † _____ *Epinephelus analogus* Gill
Striped bass _____ *Roccus saxatilis* (Walbaum)
(California) black sea bass _____ *Stereolepis gigas* Ayres
Broomtail grouper * _____ *Mycteroperca xenarchus* Jordan
Gulf grouper * _____ *Mycteroperca jordani* (Jenkins & Evermann)
Kelp bass _____ *Paralabrax clathratus* (Girard)
Sand bass _____ *Paralabrax nebulifer* (Girard)
Spotted bass _____ *Paralabrax maculatofasciatus* (Steindachner)

Formerly "spotted sand bass." Changed in the interests of simplicity and to conform with such usage as exists.

FAMILY ATHERINIDAE—Silversides

(California) grunion _____ *Leuresthes tenuis* (Ayres)
Jacksmelt _____ *Atherinopsis californiensis* Girard
Topsmelt _____ *Atherinops affinis* (Ayres)
Bay topsmelt _____ *A. a. littoralis* Hubbs
San Francisco topsmelt _____ *A. a. affinis* (Ayres)
Kelp topsmelt _____ *A. a. cedroscensis* Hubbs
Island topsmelt _____ *A. a. insularum* Gilbert

* Species previously not listed.
† Not recorded from California.

FAMILY MUGILIDAE—Mullets

(Striped) mullet ——— *Mugil cephalus* Linnaeus

FAMILY SPHYRAENIDAE—Barracudas

(California) barracuda ——— *Sphyraena argentea* Girard

FAMILY CARANGIDAE—Jacks

(California) yellowtail ——— *Seriola dorsalis* (Gill)
Pilotfish * ——— *Naucrates ductor* (Linnaeus)
(Pacific) jack mackerel ——— *Trachurus symmetricus* (Ayres)
(Mexican) scad ——— *Decapterus hypodus* Gill

FAMILY STROMATEIDAE—Butterfishes

(California) pompano ——— *Palometa simillima* (Ayres)

FAMILY CORYPHAENIDAE—Dolphinfishes

(Common) dolphinfish * ——— *Coryphaena hippurus* Linnaeus

FAMILY ECHENEIDAE—Remoras

(Common) remora * ——— *Remora remora* (Linnaeus)

FAMILY SCOMBRIDAE—Mackerels

Pacific mackerel ——— *Pneumatophorus diego* (Ayres)

FAMILY CYBIIDAE—Spanish Mackerels

Wahoo † ——— *Acanthocybium solandri* (Cuvier)
Sierra † ——— *Scomberomorus sierra* Jordan & Starks
Earlier reports of this species from California are now believed to refer to the Monterey Spanish mackerel.
(Monterey) Spanish mackerel * ——— *Scomberomorus concolor* (Lockington)
California bonito ——— *Sarda lineolata* (Girard)
Mexican bonito † ——— *Sarda velox* Meek & Hildebrand

FAMILY KATSUWONIDAE—Skipjacks

Skipjack ——— *Katsuwonus pelamis* (Linnaeus)
Black skipjack * ——— *Euthynnus lineatus* Kishinouye
Bullet mackerel * ——— *Auxis* sp.

FAMILY THUNNIDAE—Tunas

(California) bluefin tuna ——— *Thunnus saliens* Jordan & Evermann
Formerly regarded as identical with the Atlantic *T. thynnus*. Recent studies (Godsil and Holmberg, 1950) showed differences between Atlantic and Pacific specimens which, in the opinion of Dr. C. L. Hubbs and Mr. W. I. Follett, warrant recognition of the California bluefin as a distinct form, provisionally as a distinct species.
(Pacific) albacore ——— *Thunnus germo* (Lacépède)
(Pacific) yellowfin tuna ——— *Neothunnus macropterus* (Temminck & Schlegel)
Bigeye tuna † ——— *Parathunnus sibi* (Temminck & Schlegel)

FAMILY TRICHIURIDAE—Cutlassfishes

(Pacific) cutlassfish * ——— *Trichiurus nitens* Garman

FAMILY ISTIOPHORIDAE—Sailfishes

(Striped) marlin ——— *Makaira mitsukurii* (Jordan & Snyder)

FAMILY XIPHIIDAE—Swordfishes

Swordfish ——— *Xiphias gladius* Linnaeus
Because this is the only species known, the old name of "broadbill swordfish" was felt unduly long. It is called either "broadbill" or "swordfish" but, at least in California, not "broadbill swordfish." Use of "broadbill" alone is sanctioned as an alternative name.

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* Species previously not listed.
† Not recorded from California.

FAMILY XENICHTHYIDAE—Salemas

(California) salema _____ *Xenistius californiensis* (Steindachner)

The coined name "bigeye bass" has been applied to this fish but is not appropriate because the fish is not a bass. Tuna fishermen who use this species and its Galapagos relatives as bait refer to them as "salema." The fish has no vernacular in California.

FAMILY HAEMULIDAE—Grunts

(California) sargo _____ *Anisotremus davidsoni* (Steindachner)

FAMILY SCIAENIDAE—Croakers

Black croaker _____ *Cheilotrema saturnum* (Girard)
Spotfin croaker _____ *Roncador stearnsi* (Steindachner)
White croaker _____ *Genyonemus lineatus* (Ayres)

Formerly "kingfish," which is henceforth sanctioned as an alternative name because of its use in the Monterey area. In Southern California where the fish is most abundant, it is generally called "tomcod" or "tommy," and "tomcod" or "tomcod croaker" would be the name most closely approaching common usage. However, "tomcod" is reserved for *Microgadus proximus* and hence is not available. "Kingfish" is generally felt to be most inappropriate for this small and relatively undesirable species despite its local usage at Monterey. "White croaker," a coined name, seems reasonably appropriate and worth an effort to popularize.

Yellowfin croaker _____ *Umbrina roncador* Jordan & Gilbert
(California) corbina _____ *Menticirrhus undulatus* (Girard)
Queenfish _____ *Seriphus politus* Ayres
White seabass _____ *Cynoscion nobilis* (Ayres)
Shortfin corvina _____ *Cynoscion parvipinnis* Ayres

This Mexican fish, which now rarely if ever reaches California waters, has been listed as "shortfin sea bass." It, like the three species following, is caught in quantity in the Gulf of California by both Mexican and American fishermen. There the universal vernacular for all four is "corvina."

Gulf corvina *† _____ *Cynoscion othonopterus* Jordan & Gilbert
Orangemouth corvina *‡ _____ *Cynoscion xanthulus* Jordan & Gilbert
Striped corvina *† _____ *Cynoscion reticulatus* (Günther)
Totuava † _____ *Cynoscion macdonaldi* Gilbert

FAMILY BRANCHIOSTEGIDAE—Blanquillos

Ocean whitefish _____ *Caulolatilus princeps* (Jenyns)

FAMILY EMBIOTOCIDAE—Surfperches

Heretofore each species has been termed simply "perch" preceded by the appropriate attributive. The typical surf dwellers are now identified by the name "surfperch," those associated with the ocean but not primarily with the surf are "seaperch," while those of varying habitat remain "perch."

Barred surfperch _____ *Amphistichus argenteus* Agassiz
Redtail surfperch _____ *Amphistichus rhodoterus* (Agassiz)
Calico surfperch * _____ *Amphistichus koelzi* (Hubbs)
Walleye surfperch _____ *Hyperprosopon argenteum* Gibbons
Silver surfperch * _____ *Hyperprosopon ellipticum* (Gibbons)
Spotfin surfperch * _____ *Hyperprosopon anale* Agassiz
Rainbow seaperch _____ *Hypsurus caryi* (Agassiz)
White seaperch _____ *Phanerodon furcatus* Girard
Sharpnose seaperch * _____ *Phanerodon atripes* (Jordan & Gilbert)
Rubberlip perch _____ *Rhacochilus toxotes* Agassiz
Pile perch _____ *Rhacochilus vacca* (Girard)
Black perch _____ *Embiotoca jacksoni* Agassiz
Striped seaperch _____ *Embiotoca lateralis* Agassiz
Pink seaperch _____ *Zalembius rosaceus* (Jordan & Gilbert)
Shiner perch _____ *Cymatogaster aggregata* Gibbons
Island perch * _____ *Cymatogaster gracilis* Tarp
Kelp perch _____ *Brachyistius frenatus* Gill
Reef perch * _____ *Micrometrus aurora* (Jordan & Gilbert)
Dwarf perch * _____ *Micrometrus minimus* (Gibbons)

* Species previously not listed.
† Not recorded from California.
‡ Gulf of California species introduced into Salton Sea.

FAMILY POMACENTRIDAE—Damselfishes

Blacksmith — *Chromis punctipinnis* (Cooper)
Garibaldi — *Hypsypops rubicunda* (Girard)

FAMILY LABRIDAE—Wrasses

Sheep-head — *Pimelometopon pulchrum* (Ayres)
Formerly written "sheepshead." Changed to approximate more closely the prevailing pronunciation and to help distinguish this species from the unrelated marine and fresh-water fishes of eastern North America that are known as "sheepshead."
(Rock) wrasse * — *Halichoeres semicinctus* (Ayres)
Señorita — *Oxyjulis californica* (Günther)

FAMILY GIRELLIDAE—Nibblers

Opaleye — *Girella nigricans* (Ayres)

FAMILY SCORPIDAE—Halfmoons

Halfmoon — *Medialuna californiensis* (Steindachner)

FAMILY SCORPAENIDAE—Rockfishes

Bocaccio — *Sebastodes paucispinis* (Ayres)
Chilipepper — *Sebastodes goodei* Eigenmann & Eigenmann
Blue rockfish — *Sebastodes mystinus* (Jordan & Gilbert)
The "book name" priestfish was formerly applied to this fish but did not enter the vernacular. The new name reflects considerable usage.
Olive rockfish * — *Sebastodes serranoides* Eigenmann & Eigenmann
Yellowtail rockfish — *Sebastodes flavidus* Ayres
Black rockfish — *Sebastodes melanops* (Girard)
Orange rockfish — *Sebastodes pinniger* (Gill)
Vermilion rockfish — *Sebastodes miniatus* (Jordan & Gilbert)
Kelp rockfish * — *Sebastodes atrovirens* (Jordan & Gilbert)
Speckled rockfish — *Sebastodes ovalis* Ayres
Both this species and *S. entomelas* were formerly termed "widow rockfish."
Redstripe rockfish * — *Sebastodes proriger* (Jordan & Gilbert)
Widow rockfish — *Sebastodes entomelas* (Jordan & Gilbert)
Halfbanded rockfish * — *Sebastodes semicinctus* Gilbert
Honeycomb rockfish * — *Sebastodes umbrosus* (Jordan & Gilbert)
Rosy rockfish * — *Sebastodes rosaceus* (Girard)
Orange-red rockfish * — *Sebastodes helvomaculatus* (Ayres)
Greenspotted rockfish — *Sebastodes chlorostictus* (Jordan & Gilbert)
Pink rockfish * — *Sebastodes cos* Eigenmann & Eigenmann
Starry rockfish — *Sebastodes constellatus* (Jordan & Gilbert)
Tambor * — *Sebastodes ruberrimus* Cramer
Flag rockfish * — *Sebastodes rubrivinctus* (Jordan & Gilbert)
Greenstriped rockfish — *Sebastodes elongatus* (Ayres)
Brown rockfish * — *Sebastodes auriculatus* (Girard)
Grass rockfish * — *Sebastodes rastrelliger* (Jordan & Gilbert)
Whitebelly rockfish * — *Sebastodes vexillaris* (Jordan & Gilbert)
Copper rockfish * — *Sebastodes caurinus* (Richardson)
Quillback rockfish * — *Sebastodes maliger* (Jordan & Gilbert)
Black-and-yellow rockfish — *Sebastodes chrysomelas* (Jordan & Gilbert)
Gopher rockfish * — *Sebastodes carnatus* (Jordan & Gilbert)
China rockfish — *Sebastodes nebulosus* (Ayres)
Treefish — *Sebastodes serriceps* (Jordan & Gilbert)
Blackbanded rockfish * — *Sebastodes nigrocinctus* (Ayres)
Sculpin — *Scorpaena guttata* Girard
"Scorpionfish" is recognized as an alternative name.
Channel rockfish — *Sebastolobus alascanus* Bean
"Thornhead" is recognized as an alternative name.

FAMILY ANOPLOPOMATIDAE—Sablefishes

Sablefish — *Anoplopoma fimbria* (Pallas)
"Blackcod" is recognized as an alternative name.

* Species previously not listed.

FAMILY HEXAGRAMMIDAE—Greenlings

Greenling seatrout _____ *Hexagrammos decagrammus* (Pallas)
"Kelp greenling" is recognized as an alternative name.
Rock greenling * _____ *Hexagrammos superciliosus* (Pallas)

FAMILY OPHIODONTIDAE—Lingcods

Lingcod _____ *Ophiodon elongatus* Girard

FAMILY COTTIDAE—Sculpins

Cabezon _____ *Scorpaenichthys marmoratus* (Ayres)
Staghorn sculpin _____ *Leptocottus armatus* Girard

FAMILY GOBIIDAE—Gobies

Mudsucker _____ *Gillichthys mirabilis* Cooper

FAMILY BATRACHOIDIDAE—Toadfishes

Northern midshipman * _____ *Porichthys notatus* Girard
Slim midshipman * _____ *Porichthys myriaster* Hubbs & Schultz

FAMILY CLINIDAE—Klipfishes

Kelpfish _____ *Heterostichus rostratus* Girard

FAMILY ANARHICHADIDAE—Wolffishes

Wolf-eel _____ *Anarrhichthys ocellatus* Ayres

FAMILY CEBIDICHTHYIDAE—Monkeyfaces

Monkeyface-eel _____ *Cebidichthys violaceus* (Girard)
Formerly, with *Xiphister mucosus*, "blenny-eel." Both are usually simply "eel" to fishermen. Official—in these cases, coined—names were considered desirable.

FAMILY STICHAEIDAE—Pricklebacks

Rock-eel _____ *Xiphister mucosus* (Girard)
See comment above.

FAMILY MOLIDAE—Molas

Mola _____ *Mola mola* (Linnaeus)
Formerly "ocean sunfish." "Mola" is used as much as, if not more than, "ocean sunfish" and is obviously more appropriate.

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* Species previously not listed.

NOTES

NEW RECORDS OF PACIFIC SARDINE AND PACIFIC MACKEREL IN THE GULF OF CALIFORNIA

Published records for the Pacific sardine (*Sardinops caerulea*) include many localities in the Gulf of California, but they are all confined to the western shores. In recent years tuna fishermen have reported catching sardines in bait hauls made near Guaymas on the eastern side, but no specimens from this locality have appeared for positive identification. The following records are of considerable interest, therefore, since they establish the presence of the California sardine on the mainland side of the gulf, and also indicate that it may at times occur there in some abundance.

Fish collections were made in the vicinity of Guaymas, Sonora, Mexico, in 1950, 1951 and 1952 by collectors from the Zoology Department, University of California at Los Angeles. In 1950, although the area was covered intensively from January 20th until February 2d, no sardines were taken. In 1951 this area was sampled January 16th to 18th and February 8th and 9th. During this time only five specimens of *Sardinops* were taken, all at Puerto San Carlos near Guaymas, two (29 and 35 mm. long) on January 18th and three (24-29 mm. long) on February 9th. These post-larvae were found off rocky shores and no schools of sardines were seen. No specimens were taken while seining.

Mr. Norman Wilimovsky and Mr. Giles Mead of Stanford University surveyed this same area from May 27 through June 6, 1951. They collected *Sardinops* twice, both times taking many specimens, and reported seeing large schools of sardines about two to three inches in length.

In 1952 the University of California expedition again collected in the Guaymas area intensively from January 24th through February 12th. In contrast to the two former years, over a thousand specimens were taken in eight different collections, all in the vicinity of Puerto San Carlos. In addition, post-larval stages of *Sardinops* were observed in large numbers in the Puerto San Carlos area. The only adults seen were some dried specimens on the beach near Guaymas. These had been dumped from the bait basket of a market fisherman camped there. He reported that this kind of "sardina" was common there and that he caught them often in his throw net.

Although no intensive survey for sardines was made during any of our collecting, I am quite certain that these scanty data indicate a real difference in abundance of young sardines for the dates mentioned. The methods of collecting and scouting were practically identical each year, and there seems little possibility that sardines should have appeared so rare during late January and early February in 1950 and 1951 and yet actually been present in the numbers observed in 1952. No reason for the

apparent change can be determined at this time, since there is practically no hydrographic data available for this area. It is interesting to note, however, that the surface temperatures averaged about 16 degrees C. during 1950 and 1951 and about 18 degrees C. in 1952.

A Pacific mackerel (*Pneumatophorus japonicus diego*) was taken at Guaymas, Sonora, Mexico, on January 24, 1952. This single specimen, 294 mm. in standard length, was found in a fisherman's bait basket. It had been caught with a throw net and the fisherman reported that he often took them in this manner. This is the first record of the Pacific mackerel on the eastern side of the Gulf of California. Fitch (1952, p. 560) recently reported the taking of a young specimen from about 60 miles west of Mazatlán. Fowler (1944, p. 384) reports young of *Scomber colias* from 20 miles south of Mazatlán and from 22° 03′ N. Lat., 106° 42′ W. Long. These fish are almost certainly the same species identified here as *Pneumatophorus japonicus diego* and should constitute the published southern record for this subspecies. The specimens of *Scomber colias* reported by Fowler (op. cit.) from the Panama and the Galápagos are probably of the southeastern Pacific subspecies, *Pneumatophorus japonicus peruanus,* but the identity must remain in doubt until they have been re-examined. The whole question of the distribution of *Pneumatophorus* south of Cape San Lucas, Baja California, and the relationship of the populations, is urgently in need of study.

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—*Boyd W. Walker, Department of Zoology, University of California, Los Angeles, October, 1952.*

SURVIVAL OF SOME FISHES RECENTLY INTRODUCED INTO THE SALTON SEA, CALIFORNIA

The terrific increase in angling pressure in Southern California calls for the full utilization of all waters in the area; the potentials for a marine sport fishery in the Salton Sea, if realized, could make a substantial contribution.

California's largest inland body of water lies in Riverside and Imperial Counties, about 150 miles southeast of Los Angeles. The Salton Sea is about 13 miles wide by 32 miles long with an area of approximately 275 square miles. At present the surface level is at minus 237 feet HSL. It is a shallow body of water, averaging no more than 15 feet deep with a few "holes" up to 60 feet deep. Two rivers, the Alamo and New, formed mainly from waste irrigation water, enter the sea from the south. The salinity of the Salton Sea approximates that of sea water. No outlet exists, but the 78-inch annual evaporation rate in this arid climate has maintained the sea at a fairly constant level.

Prior to 1948 the only fishes present in the Salton Sea proper were the striped mullet (*Mugil cephalus*), the mosquitofish (*Gambusia affinis*),

the desert pupfish (*Cyprinodon macularius*), and possibly a few "die-hard" ten-pounders (*Elops affinis*). Near the mouths of the Alamo and New Rivers a few fresh-water fishes, mainly carp (*Cyprinus carpio*), are found.

In the summer of 1951, seining checks by Department of Fish and Game personnel indicated that the mudsucker (*Gillichthys mirabilis*) had become well established, as all size ranges were found around the periphery of the Salton Sea. The presence of this species cannot be traced to any definite introduction, but it has been rumored that some of the mullet fishermen had been attempting to raise such bait fish in the marginal areas of the sea and that corrosion of the containers permitted them to escape.

Since 1948 four expeditions have been conducted to San Felipe, Mexico, on the western shores of the Gulf of California, by the California Department of Fish and Game to procure marine game and forage fishes for experimental plants in the Salton Sea. Approximately 10,000 such fish, of many kinds, have now been planted in this body of water. In 1952 several recoveries of these fishes were made, as listed below.

On January 17, 1952, a 22-inch orangemouth corvina (*Cynoscion xanthulus*) was caught in a gill net by mullet fisherman J. H. Bible, in the southern end of the sea between Mullet Island and the new mouth (2.5 miles south of the old mouth) of the Alamo River, in "very shallow water." It was estimated to weigh between four and six pounds at time of capture. This fish represents one of the original introductions made either in May 1950 or March 1951.

On July 11, 1952, a $1\frac{3}{4}$-inch croaker (*Bairdiella icistius*) was found alive along the east-central shore of the Salton Sea near the Riverside-Imperial county line near Durmid Siding by Jack Bechtel of the Department of Fish and Game. Wave action had washed it ashore. This was very likely the spawn of individuals from either the May 1950 or the March 1951 plants.

On August 29, 1952, 11 *Bairdiella* 2.7-4.0 inches long were dip-netted by H. E. Schnarr, Chief of the Security Guard, U. S. Salton Sea Base, at our request. These were found along the water surface at night at the base dock.

On September 4 and 5, 1952, extensive trawling and beach-seining was carried out over representative sections of the Salton Sea by state biologists. Many young *Bairdiella* 2.5-6.5 inches long were found along the west shore and at one point on the east-central side (125 per 100-foot bag seine haul). This indicates that the original plants of adult *Bairdiella*, consisting of 57 individuals in 1950 and about two dozen in 1951, have successfully reproduced in the Salton Sea.

Such evidence of the successful establishment of these marine fishes in the Salton Sea gives great hope for the development of a future sport fishery, provided that food supplies hold up under concentrated predation on the naturally present desert pupfish, mosquitofish, marine worms, and plankton, or that new food organisms can be introduced.—*P. A. Douglas, Bureau of Fish Conservation, California Department of Fish and Game, October 1952.*

THE BRAMBLE SHARK (*ECHINORHINUS BRUCUS*) AT GUADALUPE ISLAND, MEXICO

During the early part of the night of September 8, 1952, two large bramble sharks were taken at the northeast anchorage, Guadalupe Island, on the yacht GOODWILL. Both were hooked and landed with rod and reel. Dead Mexican scads (*Decapterus hypodus*) were being used for bait and were fished near the bottom in 120 feet of water. The first shark, 267 cm. from the tip of the snout to the tip of the dorsal lobe of the tail, weighed 425 pounds. The second weighed 490 pounds and measured 295 cm. The weights were taken with a large balance scale and the measurements were straight line distances taken with a steel tape. Measurements appear below.

	Specimen 1		*Specimen 2*	
	cm.	*inches*	*cm.*	*inches*
Total length, tip of snout to tip of longest lobe of tail	267	105	295	116
Distance from tip of snout to insertion of pectoral fin	71	28		
Distance from tip of snout to insertion of pelvic fin	160	63		
Distance from tip of snout to origin of first dorsal	180	71		
Interdorsal space	14	5½		
Greatest girth	128	50¼	148	58½

The fish, typical of previous descriptions of the species, had two small dorsal fins and no anal fin. The anterior dorsal fin originated just a little behind the insertion of the long-based pelvics. The skin was distinctly armed with isolated tuberculate scales, each with a hard stellate base and a small spine at the summit.

Both sharks were females with ovarian eggs of two size classes; small, 0.8 cm. or less in diameter, and large, approximating 3.3 cm. The 267 cm. specimen contained 114 of the large eggs. The displacement of 35 of these eggs, which had been preserved in 10 percent formalin, was measured and the average volume was found to be 19 cc. each. There were no signs of developing embryos.

The stomach of the larger specimen was empty and that of the smaller contained only one large, almost wholly digested, gill arch.

Late in August, 1952, Mr. R. C. Carpenter, skipper of the albacore troller JON-TRU caught what could only have been a bramble shark at the same locality (northeast anchorage, Guadalupe Island). This specimen was estimated to be six feet long and over 200 pounds.

The bramble shark has been recorded from warm seas throughout the world but is nowhere plentiful. Three individuals have been recorded from California (Hubbs and Clark, Calif. Fish and Game, vol. 31, no. 1, p. 64-67, 1944). As far as is known, the 295 cm. Guadalupe specimen is the largest on record.—*Robert D. Collyer, Bureau of Marine Fisheries, Department of Fish and Game, October, 1952.*

REVIEWS

The Miami Conservancy District

By Arthur E. Morgan; McGraw-Hill Book Company, Inc., New York, 1951; xiii + 504 p. $6.50.

About forty years ago the City of Dayton, Ohio, was almost wiped out by a flood, the most severe the city had ever known. More than 300 people lost their lives and property damage exceeded $100,000,000 but these figures give only a hint of the actual horror and destruction. In the years which followed a more significant history was written by the people of that area themselves, as they worked and fought to achieve permanent control of the wild Miami River and its tributaries. Dayton has never again been plagued with floods.

Mr. Morgan's book is both a history and a text. It is thorough in its details, but it often reads like pure drama. Starting with a background of past floods and the unwise economy of half measures proposed by self-appointed experts to minimize the constant threat of floods, the book builds up to an early climax when the "Great Flood of 1913" hits the city. The rest is a complete story of the tremendous effort over nine years (1914-1922) to formulate a practical flood control plan, and to see it through to the point of finished construction and actual working condition. Maintenance and further developments through 1947 conclude the book.

One of the outstanding features of the story is the vivid portrayal of how a democratic people solved a very tough problem. Only through a combination of dynamic leadership, honest social cooperation and democratic action was the plan finished and the engineering job completed. Here, then, is a tribute to the people of the Miami River Valley and a monument to the leaders, not the least of whom was Mr. Morgan, the chief engineer. The story is augmented by numerous biographies and portraits of persons who contributed to the program, and by many newspaper excerpts which mention dates, names and places. Of particular interest is the description of the major role played by a big national industry, both in relief after the flood and in the over-all execution of the plan.

This volume brings out several other things which are worth noting. Among them is the fact that many present projects of the Department of Fish and Game present problems similar to those which were recognized and handled by the Miami Conservancy District. Especially pointed out is the danger inherent in a lack of sufficient publicity and proper public relations. An uninformed or suspicious public, led by armchair lawyers and "I've lived here all my life" characters, can block any program. One way in which Mr. Morgan overcame this resistance to the regional improvement project was to show the existence of a precedent. Precedents were not always right at hand, and often long and laborious research was required to dig them up. Nevertheless, they were well worth discovering because they helped to sell the so-called practical man who places so much weight upon this matter of example. At the same time, complaints were received from the public because of the lengthy but necessary period of gathering preliminary data, doing research and formulating the master plan. The question which seemed everywhere to confront the staff was "Why don't you *do* something?" How familiar that question sounds to many professional fish and game men!

Another section of the book describes the legislative problems confronting any new venture. The public-spirited reader may be appalled to note the staff's need to resort to many very intricate legal maneuvers in order to accomplish a straightforward project for the public good—a project which apparently could cause absolutely no one any harm. Also of interest is Mr. Morgan's discussion of personnel selection and employee welfare. Today we accept such tools and principles as commonplace, but to apply them to engineering personnel in 1914 was almost revolutionary.

This book is exceptionally well-documented, containing an annotated bibliography of 114 titles, an index of names and a general index. In addition, there are 104 photographs, including portraits, four maps, two graphs and six diagrams.

"The Miami Conservancy District" is not recreational reading. Those who are interested in history, biography, and social documents, however, will find pleasure in going through this book. For the engineer, the subject matter will be old, but it will also be complete and under one cover. Persons in the field of conservation will find much of interest and benefit regarding water problems, even though the Miami River Valley may be far from their particular geographical location. Unfortunately, there will be many people to whom the text-like presentation of some features and the inclusion of exhaustive quotes and reproductions will be boring or objectionable. Others will like the infinite small personal touches and the sincere interest the author has in human beings, per se. I feel that the book is important as a social record, as a statement of high engineering achievement and as an interesting account of an historical event.—*Herbert E. Pintler, California Department of Fish and Game.*

Freshwater Fishery Biology

By Karl F. Lagler; Wm. C. Brown Company, Dubuque, Iowa, 1952; x + 360 p., illustrated. $5.75.

Dr. Lagler has extensively overhauled his well-known earlier "Studies in Freshwater Fishery Biology," which was first published in 1947 and passed through several editions, to produce the present comprehensive text and reference work for students and professional workers in the field.

The book deals with the principles and methods of modern fishery research and management of the inland waters of North America. The 25 chapters of the book treat successively natural history and ecology, classification, identification, the literature of fish and fisheries, anatomy, embryology and subsequent life history stages, food, age and growth, populations, yield, pathology, pollution, laws, fish culture, fishery surveys, improvement of inland waters, creation of new fishing waters, and inland commercial and recreational fisheries. Numerous fish scale photographs, reproductions of fishery survey forms, a list of abbreviations, a tabular summary of some important fish diseases, and conversion tables comprise the appendices. The individual chapters are followed by lists of references, and the book is amply illustrated by 184 figures.

There is no doubt but that there has existed a pressing need for a publication of this kind in the relatively new field of fresh-water fishery biology. Dr. Lagler's book goes far toward meeting this need, although certain deficiences appear to be present to this reviewer, as described herewith.

The attempt to provide both a reference for professional workers and a study outline for students is evident and carried out by design (p. 15 and subsequent pages). In the opinion of the reviewer, this dual approach does not always work out as a happy combination. Certainly, the professional worker will often remain unsatisfied with the scope of treatment given a particular phase or subject.

As an example of the above, there is not enough detail and discussion of "Electrofishing" for the professional worker (pp. 8-10). The same comment applies to "Poisoning" (p. 10); a scant paragraph is devoted to this important study and management tool and there is no discussion of methods of application or results obtained, and no references to it are cited.

The selection of references appears to be quite uneven. Those cited at the end of each chapter are sometimes, but by no means always, the most significant or authoritative ones for the field. Some apparently were selected only to illustrate some point in the text. It is not apparent why bibliographies such as Allen, "A selected bibliography of marine bionomics and fishery investigations," Baughman, "An annotated bibliography of oysters with pertinent material on mussels and other shellfish and an appendix on pollution," Corwin, "A bibliography of the tunas," and Wheeler, "A bibliography of the sardines" are cited in a book on fresh-water fishery biology. There are some important omissions (e.g., the O. W. A. A. check list of common and scientific names from p. 37). Also, the references are sometimes inaccurately cited and difficult to locate. Not a single reference is cited at the end of Chapter V, "Fish Anatomy."

It is evident that large segments of the book are based on the fishes and practices in the north-central states. Discussion of important work done in the western United States is neglected and most western references are completely ignored. For example, in the chapter on "Stream Improvement," pp. 262-271, no mention is made of the construction of flow maintenance dams, stream clearance, or other practices and problems of western waters. There is casual mention but no discussion of fishways, a subject of great importance in western North America. Some common and representative far western fishes, e.g., all members of the genera *Hesperoleucus* and *Siphateles*, *Cottus asper*, *gulosus*, and *aleuticus*, the eulachon, *Thaleichthys pacificus*, the tidewater goby, *Eucyclogobius newberryi*, and the striped bass are all omitted from the check

list of "common and representative freshwater fishes of North America, north of Mexico" (p. 21-36).

Unfortunately, many methods described in older works are rather often cited without a critical analysis in the light of later findings. Farm ponds, which have created so many problems for fishery biologists in many sections of the United States, are treated quite briefly and casually (p. 274-275).

From a reading of the text it is evident that standardization in methods, procedures, and terminology in the field of fresh-water fishery biology is still far from realized (e.g., see p. 109).

In the opinion of the reviewer, the actual illustration of many types of blank forms used in inland fishery investigations is a very useful feature of the book.

In brief summary, it may be stated that this book is a valuable compendium of many commonly used methods and practices of fresh water fishery biology in the United States, which could be made even more useful to both student and professional worker if broadened to include certain neglected phases of the field, augmented to include important work done in the West, and supplemented with critical analyses of certain still accepted but outdated methods and practices.—*Leo Shapovalov, California Department of Fish and Game.*

A Field Guide to Shells of the Pacific Coast and Hawaii

By Percy A. Morris; Houghton Mifflin Company, Boston, 1952; xx + 220 p., 8 color and 40 black and white plates, $3.75.

This shell book could have been a very good thing. As it is, there are so many inaccuracies, it should never have been published. There are misspellings, misidentifications, wrong genders on specific names, wrong page references, poorly chosen common names, wrong habitats, wrong geographical distribution records and poor descriptions, to say nothing of a rather sad "glossary of conchological terms." The black and white plates are generally clear and quite good, but the color plates leave much to be desired. Most of the errors which appear in this volume could have been kept out with a minimum of care.

It would be impossible to detail all of the mistakes in this review, so I shall cite just a few:

(1) Misspellings: *Hiunites* in at least five places, on pages 12, 18, 44, and 215; *Plagioctenium* on page 44; *Volsella demissus* on page 21; *Platyodon* on page 58; *Prototheca laciniata* on page 72; *Opalia wroblewskii* on every page where it is mentioned; *Pholadidea* on page 97; *Diodora aspera* on page 105 and *Tegula aureotincta* on page 109.

(2) Misidentifications: Page 73, figure 1, is *Chione gnidia*, not *C. undatella;* figure 6, same page, is *C. undatella*, not *C. californiensis;* page 97, figures 4, 5, and 6, labelled *Parapholas californica, Barnea pacifica* and *Bankia* are *Parapholas acuminata, Penitella penita and Xylophaga;* on color plate 4 and black and white plate 30, figures 11 and 19 are not *Conus californicus;* on black and white plate 24, *Opalia wroblewskii* and *Epitonium boreale* are synonymous, but figures 1 and 6 are *Opalia chacei;* and, on page 136, figure 7 should be *Pterynotus rhyssa.*

(3) Poorly chosen common names, most noticeable of which are the names given by the author to several important California (Pacific Coast) species which are regulated by law and have had common names assigned to them for years. Among these: "blue" abalone for our green abalone and "corrugated" for our pink abalone; "giant pod" for *Siliqua patula*, which has had several volumes written on it and is commercially canned as the "Northern razor clam" or just "razor clam"; "Nuttall's saxidome" for our commercial "Washington clam" and "Washington clam" for the gaper. I am sure that no California clam digger would recognize the bean clam under the name "Goulds wedge" nor the bent-nose clam by the name "common macoma."

(4) Obvious poor descriptions: For *Haliotis fulgens* the statement "there are generally six open holes near the margin plus a notch at the edge," yet the illustrations on pages 28 and 100 show but five, which is as it should be; for *H. cracherodi*, the typical number is given as 8, the figures show 5 and 7 respectively—7 is most typical; for *H. rufescens* the number is given as 4, the figures show 3 and 3 it should be; the anterior and posterior sculpture mentioned for *Zirfaea pilsbryi* should be reversed and *Amiantis callosa* does have a periostracum, is not pure white, on account of the very grey periostracum, and the concentric ridges frequently divide near the center of the shell.

(5) Among the wrong habitats and ranges: *Chione fluctifraga* is typically found in gooey, black mud rather than sand, just below high or mid-tide level rather than low tide and is much more common than *C. undatella; Lithophaga plumula* often bores into large dead shells, but more often into live shells and I question including *Chama* among these; *Mya arenaria* is found quite commonly from Elkhorn Slough at least to the Oregon border and not just in San Francisco Bay; *Schizothaerus nuttalli* probably ranges into British Columbia, it definitely does not stop at Bolinas Bay, and *Pecten diegensis* ranges several hundred miles south of San Diego.

A book such as this is definitely needed on our coast and it is certainly a shame there had to be such an inexcusable number of mistakes as appear in this volume. It is hoped that the book will be thoroughly revised in the very near future.—*John E. Fitch, California Department of Fish and Game.*

The Ocean River

By Henry Chapin and F. G. Walton Smith; Charles Scribner's Sons, New York, 1952; viii + 325 p., illustrated. $3.50.

This recent addition to the list of books about the science of the sea designed for the layman deserves high rank in the group. It is concerned almost entirely with the North Atlantic and its central theme is the Gulf Stream—the Ocean River. As one would expect, it presents the scientific story in terms of geology, oceanography, and biology, with an explanation of the dynamics of this great system. Beyond that, the reader learns of the influence of the "river" on civilizations bordering the Atlantic and, particularly fascinating, the story of Atlantic explorations from the beginning of recorded history. Chapin, historian and anthropologist, and Smith, oceanographer and biologist, make a good team and get the most out of their subject.

Our Amazing Birds: The Little-known Facts About Their Private Lives

By Robert S. Lemmon; American Garden Guild and Doubleday & Co., New York, 1952; 239 p., illustrated in black and white by Don R. Eckelberry. $3.95.

Dedicated "For bird watchers of all ages everywhere," this book contains illustrations and short discussions of 102 species of North American birds, species which the author regards as worthy, for one reason or another, of the adjective "amazing." The approach is strictly nontechnical, the text is well-written, and the paintings excellent. It is a handsome volume, a credit to the publisher, and one which the bird lover will likely want on his library shelf.

REPORTS

FISH CASES

October, November, December, 1952

Offense	Number of arrests	Fines imposed	Jail sentences given
Abalone: Undersize; overlimit; taking without license; failure to show; out of shell; no measuring device	27	$785.00	
Angling: No license; possessing spear near Eel River; more than one pole; angling closed waters; extra gear; fishing near dam; snagging; failure to show license; night fishing; using another's license; transferring license; operating setline; fishing in fish ladder; illegal possession of gaff; possessing spear within 300 ft. stream; unattended pole; false statement on license application; alien using citizen's license	313	4,115.00	10
Bass: Overlimit; undersize; mutilating; bringing illegally into State; taking with more than one rod; taking without license; at night	65	1,975.00	
Catfish: Overlimit; taking without license	2	35.00	
Clam: Overlimit; undersize; failure to return to hole; using another's license; taking in refuge	102	3,022.00	
Commercial: Operating smokehouse without license; commercial fishing without license; untagged lobsters; dealer possessing lobster in closed season; undersized lobsters; using net in closed district; overlimit salmon; market possessing lobsters in closed season; operating cannery without license; no commercial license; no boat registration; waste of fish by packers; selling fish taken from boat carrying anglers; possession of sea bass on purse seiner; using roundhaul net District 20; selling untagged salmon; possessing trawl under 4½ inches; selling fresh salmon and steelhead spawn; undersize crabs; sale undersize skipjack	69	3,365.00	
Crab: Closed season; taking females	2	75.00	
Frog: Overlimit; taking in closed season	2	80.00	
Lobster: Using traps in District 19A; undersize; closed season; using aqualung	9	885.00	
Mullet: Spearing	1	25.00	
Perch: Overlimit	1	25.00	
Pollution: Oil	7	1,500.00	
Salmon: Spearing; snagging; taking from spawning beds; taking from closed stream; with gaff; at night; possession spear near spawning bed; possessing illegally and failing to show; no license; using 2 poles; shooting; closed season	62	2,560.00	
Sunfish: Overlimit; no license; taking closed season	2	75.00	
Trout: No license; taking with net; overlimit; no permit and transporting; closed season; transporting illegally into State; taking in closed area	32	1,215.00	
Total	696	$19,737.00	10
Sale of seized fish		1,949.38	
Grand total		$21,686.38	

GAME CASES

October, November, December, 1952

Offense	Number of arrests	Fines imposed	Jail sentences (days)
Bear: Carrying gun in State park and attempting to trap bear in closed season; trapping and killing in closed season; taking at night	5	$850.00	
Coot: Late shooting; taking from powerboat with 22 rifle; taking without license	4	150.00	
Deer: Failing to fill out tags; failing to retain skin and antlers; carrying extra tag and using another's tag; hunting without tags; possession untagged deer; killing in closed season; taking doe; possession artificial light and spike buck; using Utah residence license; transporting illegally; possession without permit; shooting in safety zone; taking in refuge; using "A" tag in one deer district; night hunting; shooting within 150 yds. dwelling; passing first validating officer; using illegal ammunition; possession doe and fawn; shooting from car; failure to close gate while hunting; transferring tag to another; taking deer in possession of another; taking forked horn in closed season; overlimit; possessing illegally	333	28,320.00	500
Deer Meat: Possessing meat taken in closed season; possessing unstamped meat in freezer; meat of doe; selling	40	2,210.00	705
Dove: Taking closed season; overlimit; without license; shooting with unplugged gun; transferring shipping tag; shooting from car; taking with 22 rifle; hunting from car; using unplugged gun	45	1,625.00	
Duck: Late shooting; early shooting; from powerboat; possession gun in refuge; using unplugged gun; no stamp; overlimit; using 22 rifle; taking in refuge; without license; in cooperative area without permit; illegal transportation; closed season; possession without evidence of species	435	12,912.00	
Elk: Possessing elk meat; no license; no permit; taking fully protected animal	4	325.00	
Goose: Overlimit; late shooting; using unplugged gun; nonresident hunting with illegal license; shooting in refuge; without license	32	1,065.00	
Hunting: Possessing gun in refuge; trespass in closed zone; hunting without license; shooting across highway; using unplugged gun; failure to procure nonresident license; spotlighting; transferring hunting license; shooting within 50 ft. of dwelling; failure to show license; shooting on public road; night hunting	113	4,126.00	5
Loaded gun in car	682	16,515.00	
Mudhen: Herding with powerboat; taking with 22 rifle and no license	4	110.00	
Nongame birds: Shooting marsh hawks from highway; taking glossy ibis; swan; robin; shorebirds; seagull; plover	19	525.00	
Pheasant: Taking closed season; taking hen; without license; trespass in pheasant cooperative; on cooperative area without back tag; failing to tag; using another's license and tags; using unplugged gun; overlimit; hunting closed zone; late shooting; early shooting; possessing pheasant without plumage; shooting near dwelling; possession and transporting illegally; shooting from road; with 22 rifle; taking eggs and raising without breeder's license	359	15,576.50	83
Pigeon: Taking closed season; using unplugged gun; no license	3	155.00	
Quail: Hunting without license; using unplugged gun; taking in closed season; overlimit; hunting on cooperative area without permit; bringing illegally into California from Mexico; taking in refuge; shooting from highway; shooting with 22 rifle	46	1,730.00	
Rabbit: Taking with unplugged gun; closed season; night hunting; spotlighting; without license; taking and failing to show license; early shooting	58	2,115.00	
Sagehen: Taking closed season; failure to show	2	100.00	
Sierra Hare: Taking closed season	1	15.00	
Squirrel: Taking closed season; transporting illegally	3	150.00	
Totals	2,188	$88,574.50	1,293

SEIZURES OF FISH AND GAME

October, November, December, 1952

	Number	Pounds
Fish:		
Abalone	119	
Bass	309	140
Catfish	63	
Clam	939	
Crab	16	
Frog	12	
Lobster	23	
Mackerel, jack		8,500
Mullet	5	
Perch	16	
Salmon	79	140
Sardine		31,000
Sunfish	119	
Trout	295	
Tuna		8,115
Game:		
Bear	1	20
Coot	9	
Deer	168	702
Dove	699	
Duck	592	
Elk	1	70
Goose	71	
Nongame birds	16	
Pheasant	227	
Partridge	1	
Quail	79	
Pigeon	26	
Rabbit	49	
Sagehen	1	
Squirrel	9	

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